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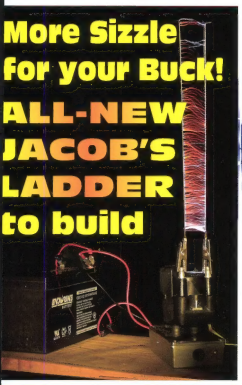

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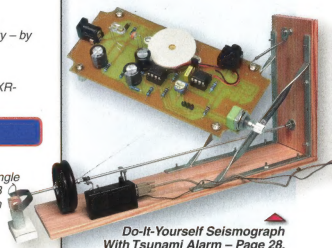

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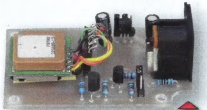

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Publisher's Letter

Texting while driving could be prevented

Today's mobile phones are wonderful pieces of technology but they are constantly being misused by irresponsible and stupid people. How many times have you seen other drivers texting while they are actually in traffic? Have you ever done this yourself? How could anyone be so stupid? But it happens all the time.

Sure, this behaviour is illegal but it is virtually impossible to police because it happens so frequently. At the risk of being labelled "sexist", this stupidity seems to be more common among young women drivers but blokes do it as well.

I would like to think that any driver who was involved in an accident while texting or using a phone would be facing a jail sentence. After all, if someone was killed, surely a charge of manslaughter would be highly probable. But even if it was, that would be no certain deterrent.

In fact, no legislation, no matter how draconian, will ever be able to prevent stupidity. I even think that any use of a phone in a car is a serious distraction when you are driving, even if you do have a hands-free set-up. I know that legislation against all phone use in cars is probably never going to happen because so many people do work from their cars.

But perhaps phones could be prevented from providing any other functions, such as texting, reading emails, browsing the internet and even track changing while you are playing music.

Technically, this would be simple to achieve, provided the phone had an in-built GPS receiver, which most smart-phones already have. The GPS would then prevent all the above-listed functions from working above a low threshold speed. In fact, the phone could probably have some input whereby it sensed that the car's engine was running. If so, most phone functions would be disabled.

The technology to do this is available right now. For example, the Australian company Humming Bird Electronics makes a GPS switch which could be the basis of this function (see **http://hmbe.com.au/products/gps-speed-switch**).

Maybe such a system should be used to disable all phone use. If this seems too drastic for all those people working from cars, then so be it. If they were waiting on an important in-coming call or needed to make some calls, they would have to pull over and stop the engine. If they didn't like it, tough!

It would not be a big step for the legislators in this country to flag up a move to have all cars fitted with such technology. It would be a condition of registering your car.

Furthermore, it would not be all that hard for this GPS over-ride device to broadcast a signal so that police cars in the vicinity can check that it is functioning. They can already easily check whether a car is fitted with a radar detector or is legally registered.

Ultimately, if Australia and other countries want to further reduce the road toll, legislation to prevent behaviour is not the way to go. Technology should be used wherever possible, provided of course, that it is cost-effective. Whether that means improving the roads themselves, the signalling and sign-posting and so on, or technical modifications to cars (and phones), so be it.

Legislation can only go so far as a deterrent against stupid and irresponsible behaviour. Technology can and should be used as well.

Leo Simpson

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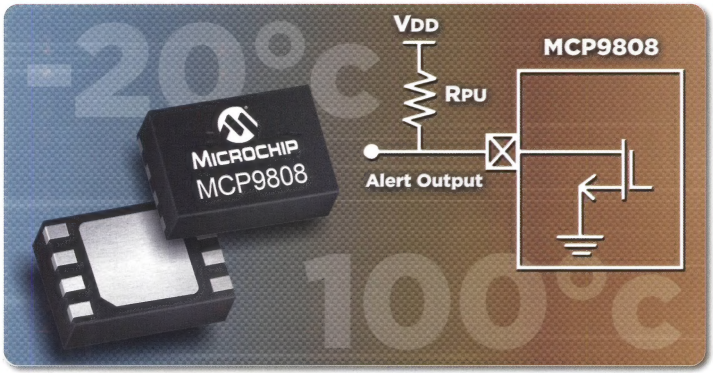

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MAILBAG

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Federal Government won't rein in power costs

While I agree with your statements about smart meters and gold plating etc (Publisher's Letter, December 2012), please don't lose sight of the aim of this "public debate". The Federal Government raised the story to divert attention from carbon tax and federal energy program waste onto the states. By keeping this ball in the air, we are serving their strategy. Let's talk about state issues before state elections and federal issues before federal elections.

As electors and being in the engineering sector we should be asking why Federal money is not being channelled into cross-State strategies such as interstate DC power transmission, regional load levelling schemes and possibly some real renewable energy projects rather than subsidies for panels on roofs.

Incidentally, why is it that government and power producers agree that it's necessary to charge high prices to supply peak demand, yet they decry the price they contracted to pay for solar power exported from home solar systems at just these peak times?

Kevin Shackleton,
Doubleview, WA.

Comments from a "valve tragic"

I also visited the Sydney Hi-Fi show and I too resisted the $160,000 loudspeakers, not to mention the gold-encrusted double-shielded monster speaker cables everyone seemed to have. I found the dipole and open baffle speakers impressive but like you I wondered what the same amount of money in a conventional enclosure would do. In the end I picked up a pair of VAF I-66 speakers at a fraction of the cost of some others. I'm more than happy!

I think it's pretty obvious that you see the worth of an amplifier in purely measurable performance terms – will it faithfully reproduce its input at its output, without adding distortion or losing bits of information? You are looking at it from a purely scientific/technical perspective which is perfectly sensible.

However, I bet when you look at a Norman Lindsay painting you don't look for technical accuracy there but rather something altogether different, something alluring and mystical. The same goes for valve amplifiers. If I wanted technical accuracy I would go for solid-state every time but I prefer valve amplifiers because they change (distort) the sound in a way I like and playing music through a large valve amplifier is never boring. It's simply more fun.

My latest valve amplifier uses eight triode-connected EL509-2s and six 6SN7s in a fully balanced "Wiggins Circlotron" circuit giving about 0.7% distortion at full 60W output/channel, -3dB <10Hz - 110kHz, all with

PWM drive to LEDs may not save power

In the article entitled "A High-Quality Digital Audio Signal Generator; Pt 1" in the March 2010 issue, there is a small inaccuracy in the description of the PWM control of the LCD backlight. On page 64, the author states, "The brightness [of the LCD's backlight] is adjusted via an NPN transistor which is pulse-width modulated . . . this . . . saves battery usage because only a low-value current limiting resistor is required".

In fact, there is no saving of power through the use of PWM here. The average current in the backlight LED at the default 25% duty cycle is about 80mA and the average power dissipated in the 5.6Ω current limiting resistor is about 145mW. If PWM hadn't been used and the resistor changed to 22.4Ω to obtain a continuous 80mA LED current, the resistor would still dissipate 145mW.

This happens because the load is a LED which is a constant-voltage device. This results in a constant voltage of 1.8V across the dropping resistor, whatever its value. Since the average current in the resistor is constant at 80mA, regardless of whether or not PWM is used, the power lost in the resistor is also constant.

With the present arrangement of the circuit, the backlight LED could be damaged in the event that the PIC's PWM output isn't properly set-up due to a transient fault or programming error. There is therefore a case for changing the current limiting resistor to 22Ω and increasing the default duty cycle of the PWM to 100%.

Andrew Partridge,
Toowoomba East, Qld.

Comment: we think your calculations assume that the LED forward voltage does not change with current drive. It does change and given the rather large level of overdrive, it is quite a significant increase, possibly close to 40%.

We think that the backlight in this unit is two LEDs in series, giving a forward voltage at the nominal current level of around 4V. At much higher pulsed currents, this could increase to around 5.5V, halving the voltage across the resistor and thus its dissipation.

You are correct that if the forward voltage stays the same, the dissipation in the resistor is the same regardless of the duty cycle, for the same LED average power.

Also consider that persistence of vision effects mean that the apparent LED brightness does not necessarily vary linearly with the duty cycle and thus pulsed drive may be able to provide a better brightness/power ratio.

NO global feedback. Connected to the VAF I-66's it sounds fantastic. Now that's tragic!

Hey, you even mentioned yourself that you like vinyl. I suspect you secretly long for the days of Pink Floyd and The Supremes, when spinning a record was an "event", much more interesting than inserting a bit of plastic in some mystery slot (within reason).

You should consider a good valve amplifier to go with your turntable; once you've had vacuum-state you'll never go back.

Seriously now, as far as a 15-inch speaker project goes, have you considered an open-baffle design? They're easy to build, relatively inexpensive, though a bit large, can be built by anybody with a large sheet of wood and a jigsaw, and from what I hear they're excellent performers when using the correct speakers and crossovers.

Anyway, thanks for a good read.

Phil Wait,
Neutral Bay, NSW.

Leo Simpson comments: I used to think some valve amplifiers were really good. I built the Mullard 10/10 way back then and I have heard some pretty good valve amplifiers since, including one built by Poul Kirk, who used to run Elan Audio in Perth. I am pretty sure he was using a nested feedback design.

I also think that most commercial solid-state amplifiers are nowhere near as good as they could be for very little increase in cost. And most home-theatre amplifiers are pretty average and arguably a good valve amplifier may well sound better.

Your example of Norman Lindsay is interesting. I am familiar with his work and must say that I regard his nudes as

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Mailbag: continued

LED lamps have poor light distribution

From experience I'd like to warn people considering replacing their house lighting with LED globes. LEDs do put out more light per watt of power used but a LED is a high-intensity directional spot source of illumination. Even a globe-shaped LED light primarily projects its light downwards, not in all directions like an incandescent bulb or compact fluorescent. It doesn't bounce light off the ceiling and walls to the same degree.

So the surface of a desk or table may be well lit but as soon as you sit at that desk to read or at that table to eat and your head comes between the light and what you are trying to eat or read, it is in shadow and harder to see. And using a higher output LED doesn't get rid of the shadow, it just makes it worse by increasing how brightly illuminated things not in shadow are.

There are LED globes that use LEDs mounted in a corn-cob shape that do project light in all directions that are much better in this regard. But the light is not emitted in a low intensity over a large area, rather from a lot of bright points, so a LED light that puts out a lot of light can be very "glarey".

LEDs are efficient and long-life but replacing existing lights with LEDs and getting a good result is more complicated that just unscrewing one and screwing the other in.

Gordon Drennan,
Burton, SA.

slightly weird; some of his work is very good though. Clearly, one does look at brushwork, anatomical correctness and other technical details in forming an overall appreciation of artworks.

Having said that, I do not think there is much parallel between the appreciation of art works which must inevitably be a combination of objective and subjective judgment and that of an engineered product where technical performance must be the main criteria for excellence.

As far a playing vinyl records is (was) concerned, I think the whole process was a ritual. One took great care of the records and the playing equipment and obtained great satisfaction in obtaining really good sound. These days you can obtain even better sound quality but the whole process is largely devoid of ritual.

Science education letter was refreshing

I, along with the Publisher of this magazine, have long had concerns about the way the science curriculum is heading – especially physics, which I taught for most of my teaching career (as well as being a HSC marker of the subject for much of it).

It was therefore refreshing to read William Andrew's excellent letter in the Mailbag pages of the January 2013 issue. Such astute observations from one so young! There is not one point in Mr Andrew's letter that I did not agree with. Indeed, his comments on the topic of AC-DC power transmission raised a smile. Some years ago, I supervised the marking of that very subject and can only say that his description is spot-on! I remember lots of scripts referring to the electrocution of cattle and execution by electric chair!

The comments on the run-down state of science equipment in most state schools are also true and this is very sad when money has been wasted on the so-called Digital Education Revolution. It was with much satisfaction that I handed my doorstop (sorry, laptop) back upon retirement.

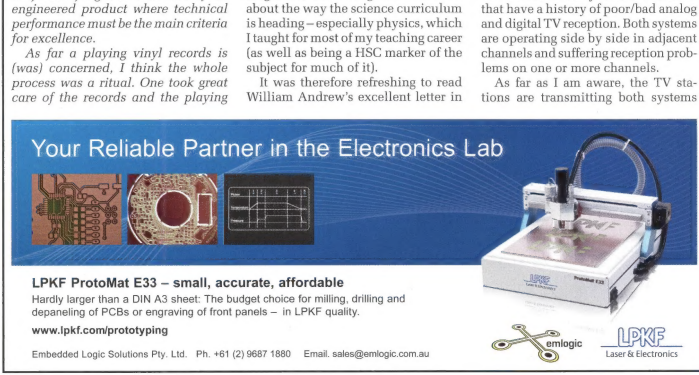
I congratulate Mr Andrew on his articulate and detailed observations of the current situation. There is yet hope for the future!

George Green,
Wollongong, NSW.

Digital TV and destructive echoes

I would like to thank Mr Ted Linney for his response (Mailbag, January 2013) to my letter in November. My comments are based on some years of experience of performing TV antenna installations at sites of difficult reception in Perth. Many sites are in areas that have a history of poor/bad analog and digital TV reception. Both systems are operating side by side in adjacent channels and suffering reception problems on one or more channels.

As far as I am aware, the TV stations are transmitting both systems



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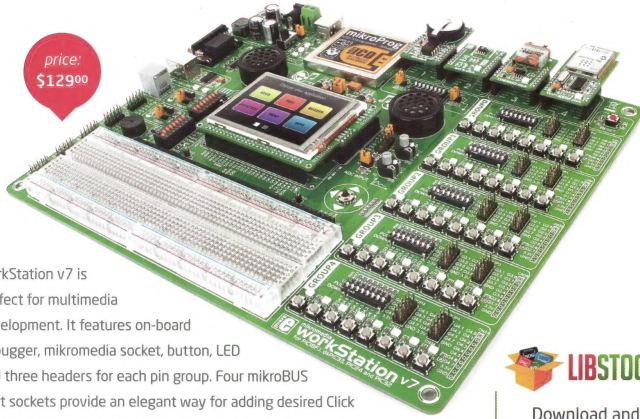

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Mailbag: continued

Many uses for a 13.8V supply

In the Ask Silicon Chip pages of the October 2012 issue, reader B. G. requested a 13.8V supply for a mobile phone charger. I wondered why B. G. wanted this supply, as most, if not all, mobile phones when purchased are provided with a mains charger and car chargers need to be purchased separately if required. Maybe there is some reason why he or she needs to go this way.

However, I have found that such a power supply as described has a myriad of other uses. Mine was bought over 30 years ago; it had screw terminals for the output and I added a cigarette lighter socket.

It has proved invaluable over the years for bench testing automotive accessories such as GPS navigators and the MP3 FM modulator that I bought today.

Jaycar sells exactly the unit requested, Cat. MP-3575 ($39.95), giving a regulated 12V output at 7.5A.

A less expensive option is to buy a cigarette lighter socket (PS-2003 at $3.95) and a regulated plugpack such as the MP-3486 ($21.95) which gives 12V at 1.5A. This of course requires some technical skill to connect the socket to the plugpack's output, and get it in the correct polarity. I have no idea of B. G.'s level of expertise, so this method may be out of the question.

Greg Mayman,
Dover Gardens, SA.

from the same mast or tower. The only thing common to the systems are the transmitting and receiving sites and the radio propagation path. In many cases, the analog system suffers from ghosting due to echoes. All my domestic TV tuners and my DVB-T meter are commercially available items sold to the general public. They are not specially designed and tested as would be expected of broadcast-quality test equipment.

The DVB-T papers I've read have often related to computer studies and reported field strength measurements performed at a standard height of 10m in the street using a mobile set up. The research workers have been aiming for a high percentage of coverage at an acceptable bit error rate.

I have yet to read a paper in which the research workers installed stationary antennas in a wide range of domestic situations subject to difficult reception conditions (ie, strong multipath) and used commercially available TV tuners/sets on general sale to the public.

During antenna installations, measurements have continually been made of signal level and bit error rate and to a lesser degree spectrum analysis and echo delay. In general, most measurements were made at the antenna or a low noise masthead amplifier close to it. The Post-Viterbi (PvBER) measurement has been the most useful measurement to determine success (better than 10^{-7}, 10^{-8}) or failure (less than 10^{-3}, 2×10^{-4}). Regardless of the reception result and the antenna used, most of the echo delay measurements have indicated all echoes to be inside the "Guard Interval".

At sites of difficult reception, the fixed TV antenna is subject to signals from the direction of the TV station and any number of echoes from any direction. These can combine to cause complex standing waves of signal strength and corruption of data. Predicted signal levels can be rendered meaningless. This mechanism can render signals typically 10-20dB below calculations.

Sometimes the spectrum analysis display shows one of two types of bite or chunk out of the channel spectrum, triangle-shaped and V-shaped. This bite can be 10-20dB or deeper and extend typically 30% or more of the channel bandwidth. The results differ from station to station, mainly depending on path profile, frequency

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and the location, size and orientation of significant reflecting surfaces.

In the early stages, the likely location of some of these echoes indicated they were coming from the back half of the antenna. Investigation of the radiation pattern of some of the typical antennae being used showed some designs had poor front-to-back (F/B) and front-to-rear (F/R) characteristics.

After replacing the antenna with one of better F/B and F/R and often relocating it to a position of improved PvBER, some or most echoes were significantly decreased or eliminated and the channel became viewable. This was the proof there can be destructive echoes inside the "Guard Interval" and that they can be overcome.

As I understand things, the 7MHz 8K DVB-T signal is made up of 6817 individual carriers spread across a nominal 6.66MHz bandwidth at a spacing of 977Hz. Of the carriers, 6004 are used to carry data and the remaining 813 are used for synchronisation and control. These are classified as Continual Pilots, Scattered Pilots and TPS Pilots. The triangle-shaped and V-shaped bites of the channel spectrum mentioned above are, I suspect, the result of a gradual cancellation of a large number of sequential carriers as the echo passes from one Fresnel Zone to another.

I am referring to the echo crossing tens (or more) of Fresnel Zones before combining with the direct beam from the transmitter. When a significant echo reflects off a surface that is an odd number Fresnel Zones from the direct beam, the energy reinforces the signal and an even Fresnel Zone results in reduction of signal. What I am saying is that a fixed reflection surface that's far enough away from the main beam can cause a bite or chunk out of the multi-carrier DVB-T signal over a significant portion of its bandwidth.

I am advised by a television station engineer that a loss of about 25% of the Continual and/or Scattered Pilots in the DVB-T signal can result in a break-up of the signal. Possibly this may be occurring due to an echo or echoes cancelling sufficient pilots. Unfortunately, I do not have the tools to give me such detailed information.

What is clear is that a significant reduction or elimination of some echoes results in improved PvBER and often a fuller spectrum. That is, echoes can be destructive and can occur in the "Guard Interval".

In my experience, it has generally been echoes that cause reception failure, not low signal level per se. Some can cause reduction and/or corruption of signal and have been inside the "Guard Interval". The main requirement for successful reception is a good PvBER. In sites of difficult reception, this can be achieved by the suitable selection and location of the antenna in many cases. This can result in the signal being low but of good PvBER.

Circuits should have component numbers

I find it annoying that in your schematics, parts lists and PCBs you don't label ALL resistors and ALL capacitors with BOTH value and component number. Most CAD packages insist that you give all components a component number so why don't you provide this in your description? It takes no more effort.

SILICON CHIP is the only organisation I know that does not number components. I believe component numbers on PCB are more important than the component values that SILICON CHIP currently provides. I find component numbers are vital in debugging and fault finding. I am surprised that you can debug a circuit without component numbers.

When I was building your USB Data Logger I had a problem with the power supply and I found it very frustrating trying to identify components on the PCB from the schematic.

Peter Kay,
Dromana, Vic.

Comment: the reason why we don't put component numbers and values on the diagrams is simple: we want to keep them as uncluttered as possible. We think that this makes the circuit easier to follow.

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Mailbag: continued

Low voltage domestic power distribution

I wish to suggest some projects and articles for SILICON CHIP in in 2013 and for several years to come. They are all inter-related and are as follows:

(1) Domestic low voltage DC distribution;
(2) A series of designs for high-efficiency regulators with 12V or 5V outputs to plug into the distribution system;
(3) Universal (or a series if necessary) PWM constant-current regulators for LED lighting;
(4) A series of dimmable triple regulators for tri-colour LEDs, taking account their different forward voltages; and
(5) Articles on powering the domestic distribution system directly from solar or other off-grid sources.

With domestic distribution, apart from providing an alternative to the millions of plugpacks we currently use, it could be driven from a solar source. There is a need to set some voltage standards and to define some outlet standards. Thereafter, it could be wired per the current wiring rules.

As a first bid for voltage, I would suggest centre-tapped 48V, with most items using 24V. It is safe and would be more tolerant of voltage drops than perhaps a 12V-0-12V system. However, this is a matter which should be discussed widely.

The other matter is getting suitable outlets and plugs. I favour a 3-pin, polarised system with a flat pin plug which is not like any of the existing plug systems but permits a user to wire to the two outer wires or between the centre pole and one outer as needed. Again, this is a matter for design in cooperation with accessories manufacturers but the re-use of existing pin designs would be feasible.

The existing Jones plugs have flat pins which have a rating of 10A, which should be more than adequate for most applications. As it is ELV, switching of outlets is not necessary. Whilst primarily aimed at computer and entertainment areas where plugpacks abound, it could also come in handy in offices, helping to eliminate the multiple multi-outlet plug boards.

As I understand it, Standards Australia requires any new standard to be produced at virtually nil cost to them, so we (SILICON CHIP and its readership) would

When this occurs, a suitable low noise masthead amplifier close to the antenna can be used to deliver a good signal to the TV tuner/set. If the signal has a poor PvBER, the use of a masthead amplifier will do nothing to improve the situation.

The authorities implementing DVB-T transmissions do have coverage problems to overcome. In Perth, for example, they are planning to install a Band 5 UHF Single Frequency Network for five stations for this reason. Coverage estimates can be seen on the Digitalready website.

I understand that such measures are also being imple-

need to do the work which would form a very interesting project. Rather than making this an Australian Standard we should perhaps aim for an international standard! There is an IEC standard but it uses round pins.

Having eliminated mains-operated plugpacks, there will still be need to provide mainly 12V and 5V supplies. I for one would appreciate a small regulator with about five USB outlets to enable me to have a single source to charge iPhone, iPad and sundry other devices demanding a USB 5V supply. Similarly, 12V is required for other uses such as LED strip lighting, modems and routers.

High-power LED lighting appears to need constant current for best performance and life. It would appear that PWM is likely to give the highest efficiency and be the most flexible. High-power LEDs of which I have experience run at currents from 300-1500mA and will have forward voltages from about 5V to 35V. While a huge power span for a single design, surely design principles can be shown and several designs produced.

Tri-colour LEDs offer a further challenge in that the forward voltage of the red LED(s) is lower than that for the blue and green LED(s). A constant-current driver compensates for this. However, I am not sure how the three regulators will perform and track under dimming control. It would seem as though there could be another microcontroller project here to get the light output in each channel proportional to the input signal.

Finally, as most PWM designs have a pot or variable resistor buried in the ramp generator, it would be nice to have an external input of 0-10V per channel; the standard input from an analog lighting control unit. (I won't even tempt you to try DMX to analog conversion!)

It seems crazy to generate solar power at about 60V, convert it up to 230V, feed it back into the grid and then convert it back to ELV in a myriad of plugpacks to use at between 5V and 12V. It is also likely that a 230V storage battery will cost more than an equivalent LV unit

Thus, setting up a 48V domestic supply (or such other voltage as determined in item 1) in a building offers an opportunity to consider skipping the 230V stage and feeding loads directly from the battery. It becomes an opportunity to minimise losses, avoid the mains grid and provide blackout protection. And we are talking here of many of the power consuming devices which are on during peak demand periods.

Bob Lions,
Killara, NSW.

mented in other capital cities. Where I have installed TV antennas at a difficult location in this area, City Beach for example, the main reception problem to overcome has been due to destructive echoes.

In summing up, I repeat that my field experience indicates that destructive echoes can occur inside the "Guard Interval" of the DVB-T signal. In many cases, this can be overcome with the suitable selection and location of the antenna.

Mike Hale,
Maylands, WA. SC

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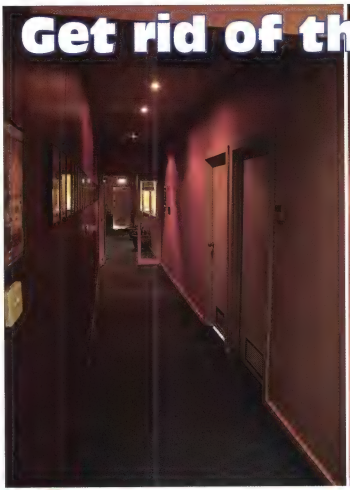
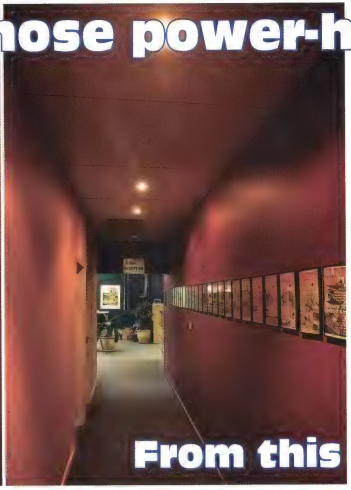




Fit these 10W & 13W LE

Got lots of 12V halogen down-lights? Is your electricity bill killing you? Maybe you should think about replacing those power hungry down-lights with efficient LED down-lights.

By LEO SIMPSON

We know that home decorators love 'em but 12V halogen down-lights are a scourge. Because they are low voltage, consumers think that they are "low power". Big mistake.

Typical 12V halogens are rated at 50W but that is just for the lamp. Add in the power used by the step-down transformer, and you can easily be talking about 60 to 65 watts per lamp. And how many of those do you have in a typical room? Eight? Ten? Even more?

That means that when you have the lights on those rooms you can easily be pulling 500 to 650 watts. Run those lamps for five or six hours a day and you can easily be paying more $300 a year, just for the lamps in one room.

We know of one home-owner living on Sydney's northern beaches (where the year-round climate is very pleasant) who complains about her quarterly electricity bill being over $1300 and she has to pay for gas for cooking and hot water as well!

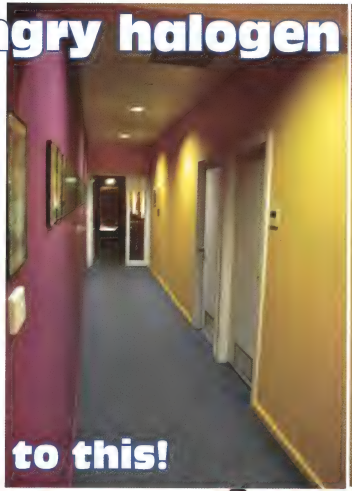
The energy costs are so high that she is thinking seriously of down-sizing. But guess what? Almost every room in this large 3-level house is lit by 12V 50W halogen down-lights. In total, there are some 50+ halogens – if they were all on simultaneously, the total lamp load would be over 3 kilowatts.

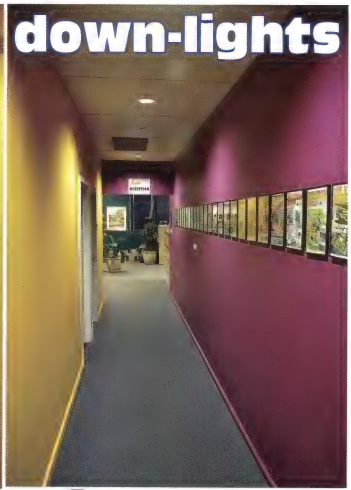
Worse still, in summer that lamp load adds to the amount of cooling required from the air-conditioner.

Working out how much extra load is placed on the air-conditioner is not straightforward. You need to allow for the aircon efficiency in cooling mode but if you have 2kW of lamps on, and the aircon is on as well, you are probably talking about a 3kW load; at least.

Run that for five or six hours a day and it is likely to cost about $2000 per annum, at Sydney's present electricity tariffs. Thankfully, this home-owner does not have a "smart meter" otherwise she would be really being punished.

Once you add in the cost of running items like a swimming pool pump, the air-conditioner itself and other appliances,





down-lights instead!

it is easy to see how a large household could have a power bill of $1300 a quarter or over $5000 per annum. So as far as we are concerned, those 12V halogens have got to go.

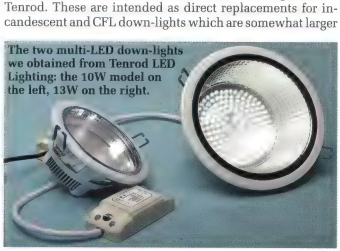
We have a slightly different problem in the SILICON CHIP offices. While the offices themselves are lit by efficient fluorescent troffers (see "Slash your factory/office lighting bills", SILICON CHIP, May 2010), we have an entry corridor which is lit by four 12V 50W halogens. In fact, while I say "lit", it is actually rather dim and gloomy (there are no windows) and while I am tempted to keep these lights off during the day because they are so power-hungry, turning them off means that we have a dark and forbidding tunnel. Well, it is not quite that bad but it is not all that attractive for an office entry.

Not only that, but since these lights are on for around ten or more hours a day, and considering that our present tariff is $0.341/kWh + GST, the annual cost for those lights alone is relatively expensive at around $240 per annum and that is without allowing for the additional air-conditioner loading during the summer.

So while our problem is minor compared to our frazzled northern beaches home-owner referred to above, it is still one that I would like to fix.

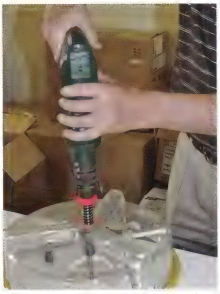
Sure, we know that you can save some power by substituting 35W halogens for 50W units or better still, using LED replacements but the 35W approach is merely nibbling at the problem and the MR16 LED halogen replacements are still relatively expensive. And even then, you would still be running those inefficient 12V step-down transformers.

Recently though, a press release crossed my desk and I pounced on it. It was for 10W and 13W down-lights, from Tenrod. These are intended as direct replacements for incandescent and CFL down-lights which are somewhat larger



The two multi-LED down-lights we obtained from Tenrod LED Lighting: the 10W model on the left, 13W on the right.

First step was to disconnect the existing halogen downlight – invariably, these days, they simply plug in. While you are up there, make sure there are no power cables etc in the way.



We elected to remove the ceiling tile to cut the hole, mainly because there was an existing downlight hole. But you could easily cut it "in situ" – in fact, installers would normally do this.

A couple of seconds later and the hole is cut. We clamped a sheet of particle board underneath the panel to give us some guide as to where to cut the hole – again, we wanted it in the same place as the existing halogen lamp hole. If this were being done "in situ", ie, cutting the hole upwards, all the dust and bits would have been safely caught in the large clear plastic cowl, without any mess on the floor below. We wouldn't mind betting that commercial installers, by now, are salivating at the thought!

than 12V halogen down-lights but why not use them anyway? We duly arranged for some sample units for this report.

Two units are available, rated at 13W or 10W and they are available in warm white or daylight white. You can see their specs in the accompanying table. My immediate reaction on receiving the sample down-lights was that they are much more attractive than typical down-lights fitted with CFLs (compact fluorescents) and would would probably give a more even light distribution. And so it has proved to be.

Our first step in doing this report was to take some photos of the corridor when the halogen down-lights were on. As you can see, the corridor is really quite dim, pools of light puncturing the gloom. Why home decorators regard these lights as attractive is beyond me!

Our second step was to pull down one of the panels with its halogen lamp and transformer and measure the power consumption. It was around 62 watts. Just for the exercise, we substituted a 35W halogen and the total power consumption dropped to 45 watts. And for the sake of completeness, we substituted a LED replacement and the power dropped further to around 11W, with 5W of that being for the transformer alone. In each case though, there was a commensurate drop in brightness.

So then we hooked up a 13W down-light from Tenrod and the power consumption measured 13 watts (funny that!), and that includes the electronic driver unit. The 10W downlight measured 10 watts, too. Then I decided to have a look at the light distribution of one of the 13W down-lights when temporarily positioned just below ceiling level in the corridor. The overall impression was that it gives a much wider pool of light and if you refer to the table, this is to be expected since the beam angle is 90°; much wider than the typical halogen lamp beam width of 60°.

Based on that test, I decided that we could probably get away with three 13W down-lights for the corridor instead of four 50W halogens. That would mean a power saving of (4 x 62) – (3 x 13) = 209W. Wow, that is a saving of 84%! That would mean a saving on the annual power bill of around $200 (again, not allowing for changes to the air-conditioning load).

There is yet another very good reason for replacing halogen down-lights with LED models and it's not that the halogens don't last all that long. Because of the current drawn (12V/50W = ~4A), all wires and contacts (eg, between globe and holder, and between fitting and transformer) tend to oxidise quite quickly, leading to increased resistance. This means increased heat (with attendant fire risk – and firies will tell you of innumerable examples of that) and also of less-than-reliable operation.

One user we know had several particularly troublesome halogen down-lights where bulbs failed regularly and often flickered and dimmed. They were fitted in a difficult-to-get-to kitchen fitting which cannot easily get rid of heat.

He's has had to replace the lamp holders and lamp leads

Altronics Hole Cutter: "a magic bit of kit"

This is the hole cutter which has the Editor so enthusiastic. It's the "Model Power X-625 Multi Functional Hole Cutter" and it's available from Altronic Distributors (www.altronics.com.au) for $175.00 (Cat T2314) and includes the large carry case.
It can be set to cut holes from 40-270mm diameter in plasterboard, plywood, acrylic sheet, etc. No, it's not cheap, but if you're involved in installing any type of audio, lighting, fans – anything needing a hole in the ceiling, this is the one you want!

It's then simply a matter of holding the two spring clamps out of the way and placing the new lamp housing in the new hole. This whole process takes but seconds, especially using the Altronics hole cutter.

several times and when removed, the wires and lamp holder were always oxidised and brittle. LED replacements would mean less current, less heat, less replacement, less aggro . . .

Doing it

In our case, we were dealing with a suspended ceiling which has Gyprock panels measuring 1200 x 600mm. Rather than cutting the required holes in situ, we decided to pull each panel down and do the job in our warehouse.

Furthermore, rather than messing about with a jigsaw to cut the 155mm holes, we obtained a rather fancy hole-saw from Altronics (Cat T-2314) .

Called a "Model Power X-265 multi-functional hole cutter", this is a magic bit of kit and would be a boon to anyone installing down-lights, flush loudspeakers, ceiling fans or anything with a circular mounting hole.

It has a central drill and a cutting bar with two adjustable blades and it will do holes from 40 to 270mm in diameter in material thickness from 5 to 50mm thick.

You just mark and punch the centre-point of the required holes, position the central drill on the punched depression and whammo, the hole is done in less than a second. But the beauty of the X265 is that it has a large transparent cowl which traps all the dust and chips so that the mess is contained. More importantly, when drilling "upward" you don't get an eye-full of debris which can put a dampener on the whole job. This tool is not cheap but it is a great advance on ordinary hole saws (which in the size required – 165mm – are also not cheap!).

However there is a problem when you want to cut a larger diameter hole centred on an existing hole for a halogen down-light. We solved that problem by clamping a sheet of

TENROD LED DOWN-LIGHTS: brief specifications

Model	10W	13W
Voltage:	100-240V AC	1000-240V AC
Beam angle:	90°	90°
Working temperature:	-20-40°C	-20-40°C
LED luminous efficacy:	>100lm/W	>100lm/W
System efficacy:	>55lm/W	>60lm/W
Lifetime:	35,000 hours	35,000 hours
No of LEDs:	104	165
Size:	130mmφ x 102mm	183mmφ x 100mm
Hole size for installation:	114mm	160mm
Colours available:	Daylight White or Warm White	
Light output:	steady state light – no strobing, no flickering	

Here's the view from the opposite side. This also shows the scorch marks on the Gyprock from the old transformer: if it can do this, imagine how much heat you're throwing away when ever the halogen downlight is on! Bring on the LEDs!

12mm chipboard to the ceiling panel and marking the new centre-point on that. If you are doing the same retro-fit on an existing plaster board ceiling and you want to use the X-265, you might be able to get around the problem by off-setting the new cut-out with respect to the smaller original cut-outs. But in any case, as we subsequently confirmed, the wide beam of these 10W and 13W units from Tenrod means that you too may be able to get away with less down-lights than you currently have.

Mini mains terminals

If we have one criticism of the Tenrod fittings, it is the uber-tiny size of the terminals you need to connect the mains wiring to.

We elected to use the two-wire mains leads fitted to the existing halogen down-lights (why buy new ones – we weren't going to use the halogen down-lights again?). The Clipsal transformers on the old units had nice large terminal blocks but the Tenrod units have these tiny little blocks with spring-loaded connectors, which make it quite difficult to fit mains wires into – certainly not without tinning them with solder to keep them stiff enough to insert.

This is not just a criticism of the Tenrod units – we've found in recent time most stuff coming out of Asia has similar connectors – and we get just as frustrated with them!

Anyway, the photos tell the story of our installation. Instead of being dingy, the corridor is now brightly lit and welcoming. It is a great result.

Final comments

If you have dimmable 12V halogen down-lights be aware that these LED down-lights are not dimmable. That is usually not an issue in office, retail or commercial installations but it might be important for domestic installations.

We should also comment that these LED down-lights make a great conversions from existing CFL and incandescent down-lights. They are more attractive to look at, give much better light, draw much less power and will last a very long time since rated life is 35,000 hours. At 10 hours a day, five days a week and 50 weeks a year, they should last at least 14 years! SC

For further information, contact Tenrod LED Lighting, 1/24 Vore St, Silverwater NSW 2128. Tel (02) 9748 0644; Web: www.tenrod.com.au

THE HISTORIC RUBICON HYDROELECTRIC SCHEME

By
Dr David Maddison

Very few people would have heard of the historic Rubicon Hydroelectric Scheme – it's not in the national consciousness like the Snowy Mountains Scheme. But at one time it was a significant source of power, supplying almost 17% of Victoria's electricity.

Located about 140km east of Melbourne, construction of the entire scheme was completed in 1929 (but some parts became operational in 1928) and it is still in operation and largely original condition, although now it generates just 0.2% of Victoria's electricity.

It is an early example of a system using remote control and fault monitoring technology. It had a number of automatic features to shut the system down to prevent damage in the event of a fault condition.

At one time it coexisted with major logging operations in the area and it has survived numerous bushfires. In addition, its environmental impact is relatively low.

The Rubicon Scheme has very much a rustic "steampunk" aura to it and was built in a time when engineering infrastructure was built to last and remain productive for an almost indefinite time. One might surmise that the reason for this was that the rate of technological progress was much slower then than now.

It made sense to build infrastructure that lasted the long periods of time expected until new technological developments had been made. In any case, some engineering solutions are universally applicable and at the macro level, if this scheme was constructed now it may not be much different to that implemented.

The scheme includes four hydroelectric power stations ranging in capacity from 300kW up to 9.2MW, for a total capacity of 13MW as shown in the table below. The maximum output is achieved during winter.

Until becoming privately owned (by AGL), the Rubicon Scheme was the oldest publicly-owned hydro scheme on

Power Station	Total Capacity (MW)
Royston	0.8
Rubicon Falls	0.3
Rubicon (two turbines)	9.2
Lower Rubicon	2.7
TOTAL	**13**

Inlet side of the Royston Power Station showing penstock. As power stations go, it's not the largest in the world . . .

the Australian mainland. The 2MW Duck Reach Power Station in Launceston, Tasmania was an older publicly-owned scheme but is no longer operational, having operated between 1895 and 1955.

To put the Rubicon Scheme's capacity into perspective, consider that the total installed hydroelectric capacity in Australia is currently 8,186MW which is about 16% of total electricity generating capacity. However the total power produced by hydro is about 5% as it is not operating at capacity. This scheme represents about 0.16% of Australia's hydroelectric capacity.

How the scheme works

The hydroelectric scheme involves two rivers (Royston and Rubicon, both tributaries of the Goulburn River), four power stations, three dams, various aqueducts, penstocks (the pipes that convey water to the turbines), roads, power lines and switchgear and associated (but now unused) infrastructure such as an industrial tramway and trestle bridges.

The first (most upstream) power station is the Royston (0.8MW). The water for this is supplied by the Royston Dam on the Royston River and is conducted to the station via about 2km of aqueduct and then a penstock of 549m in length.

The outlet side of Royston Power Station with water discharged into aqueduct. Yes, it really is a big "tin shed".

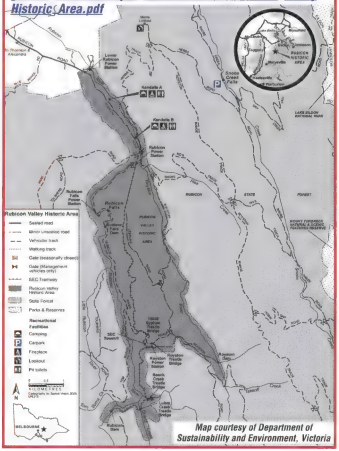
A closer look

For those people interested in taking a closer look at most of this system they can go on a 15km bush walk starting at Rubicon Power Station.

Along the trail it is possible to view the Rubicon Falls Power Station, the Rubicon Falls Dam, the Royston Power Station, beautiful scenery, aqueducts, old sawmilling and power station tramways and historic sawmill sites. The walk can be completed within one day.

Note, that as with any bush walk you should only attempt it if you are suitably equipped and experienced. It is not the easiest of walks for the inexperienced, especially the final descent. Unfortunately, the power stations can be viewed from afar but no internal access is permitted. (See a suitable bushwalking guide book for the specific route.)

The area can also be visited by an appropriate off-road vehicle, subject to seasonal road closures. See ***www.dse.vic.gov.au/_data/assets/pdf_file/0017/101744/Rubicon_Valley_Historic_Area.pdf***



An 8.8km aqueduct delivers water to the Rubicon Power Station. Note part of the disused industrial tramway track (2ft gauge) to the left.

The forebay at the end of the aqueduct that delivers water to the Rubicon Power Station. The function is to collect the water and ensure debris is trapped and removed before the water is discharged into the penstock.

The water discharged from Royston enters an aqueduct, the flowing water from which is also used to power a saw mill which is no longer in regular use except for historic demonstrations.

Rubicon Falls (0.3MW) is the second power station downstream in the scheme. Water is supplied to this via the Rubicon Falls Dam by a 420m long penstock.

The Rubicon Power Station is the third downstream and most powerful power station in the scheme with two turbines generating up to 9.2MW. Water for this station comes via the Rubicon Dam on the Rubicon River.

To reach the Rubicon Power Station the water travels along an aqueduct for a total of 8.8km. Along the way, the discharge water from the Royston Power Station (the first of the power stations) also flows into this aqueduct. A disused industrial tramway track (2ft gauge) follows the aqueduct's path. This track could not now be used without major works as the track has been warped in places from the heat of bushfires and log-falls, among other causes. It operated until the 1990s.

The forebay

At the end of the aqueduct the water is discharged into a "forebay". This consists of a water-collecting pool and grates to trap logs, sticks, leaves, rocks and other debris that has fallen into the open aqueduct, to prevent it from

The Pelton wheel

The Pelton wheel is a highly efficient type of water impulse turbine. Its efficient design means that nearly all the useful energy (>90%) is extracted from a water jet that impinges upon the turbines' buckets (the impulse) transferring kinetic energy from the water jet and causing the turbine to spin.

After the main work has been done, just enough kinetic energy is left in the water to remove itself from the bucket.

This is achieved by causing the impinging water jet to be deflected a nominal 180° (a "U-turn" but in practice, a little less) within the bucket which results in most of its kinetic energy being transferred to the wheel.

Based upon mathematical considerations, for optimal efficiency, the velocity of the water jet is designed to be twice that of the bucket.

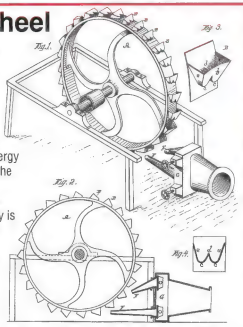
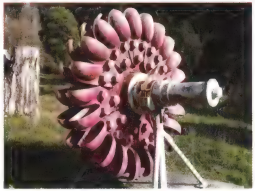


Diagram of typical Pelton wheel from original 1880 US Patent US000233692.



Pelton wheel on display at Rubicon Power Station. This power station has two generators, each of 4.6 MW capacity and each using a horizontally mounted Pelton wheel. Note the side-by-side bucket arrangement and the heavy structure of the wheel. This was one of the original wheels used at the station and was removed when the station was upgraded for increased power in 1954-55.

Often, in order to achieve better mechanical load balancing, two buckets are mounted side to side on the wheel as is the case for the Rubicon Power Station.

The Pelton wheel is a commonly used type of turbine in hydroelectric installations and excels in cases of relatively low volume flow with a high head.

The penstock leading to the Rubicon Power Station. The elevation drops 443m over a pipe length of 1305m. Note the riveted pipe construction. As the pipe descends toward the bottom, more rows of rivets are installed to cope with the extra pressure. Modern penstock pipe would be of seamless construction with welded joints if made from steel or be of a composite construction such as fibreglass.

going into the penstock and then damaging or destroying the turbines. It also has an important safety function to prevent people who may have fallen into the fast-flowing aqueduct getting sucked into the penstock. At the forebay they presumably could safely extricate themselves from the pool of water.

The forebay discharges water into the penstock, where it falls a vertical distance of 443m over a pipe length of 1305m, after which it is directed into twin Pelton wheel turbines (see box).

Lower Rubicon

The final power station in the scheme is the Lower Rubicon Power Station (2.7MW). It utilises the discharge water

Remote control and fault monitoring

The remote control and fault monitoring functions implemented within the system were remarkably advanced for the time.

Remote control was possible for opening and closing circuit breakers, starting and stopping a station and changing the electrical load of a station.

There were also safety interlocks to prevent starting of a station under a fault condition; shutting down a station if a fault was detected; only allowing as much power loading as the available quantity of water could generate and prevention of power loading beyond operational limits.

Automatic station shutdown would be initiated under the following fault conditions: bearing overheat, generator field failure, electrical overload, electrical insulation failure, over-voltage, single or reverse phase generator operation and generator over-speed.

Remote monitoring of water parameters was also possible including stream flow, aqueduct flow, pondage water level and water flow at the turbine.

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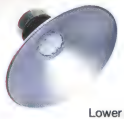

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Rubicon Power Station showing penstock running down the hill, the corrugated steel shed containing generating equipment and the switchyard at left. The discharge aqueduct and control gates are in the foreground.

from the Rubicon Power Station which travels 3.2km along an open aqueduct before entering a 320m long penstock. After this, water is discharged back into the Rubicon River, most of its useful energy having been extracted by the hydroelectric system.

Old disused tram car which was once used for conveyance of goods and equipment precariously poised at the top of the hill above the Rubicon Power Station near to the forebay. Access to the Scheme infrastructure is now by dirt roads.

View (from afar) through the window of the Rubicon Power Station showing some of the equipment.

The Future of Hydro in Australia

In recent times there has been a shift from large-scale hydro-generation to small-scale generation because most areas suitable for large scale generation have been fully exploited (eg the Snowy Mountains Scheme) or there are environmental concerns with further large-scale development. Also, since Australia is topographically reasonably flat, there are limited opportunities for hydro-generation compared with many other countries. Nevertheless, there remain some opportunities for exploitation of hydro resources at smaller scales, where the environmental impacts are of much less concern.

Hydroelectric power can be economical and comparable to the cost of coal and gas-fuelled electricity production as well as nuclear. However, no political party in Australia is prepared to consider nuclear electricity in a serious manner. Hydro is still cheaper than "green" alternatives such as solar and wind. Perhaps for economical electricity production in the future, a choice has to be made for further limited hydro production with environmental impacts versus a nuclear option with few environmental impacts but significant political contention.

Author's note: The owners of this power scheme, AGL, were invited to participate in this story but unfortunately were unable to provide any personnel familiar with the system and so information has been obtained from various other sources. SC

Smaller Scale Hydro

Commercial hydro-electric generation does not need to be large in scale (of the order of hundreds of megawatts).

There are many small scale commercial (and also grid-feed) hydro generation projects in Australia ranging in capacity from a few kilowatts to a number of megawatts such as the Rubicon Scheme.

According to one definition, "small hydro" refers to any hydro scheme below 30MW in size.

Examples of some randomly selected smaller scale systems of different vintages and different areas of Australia and New Zealand include:

Steavenson Falls at Marysville, Vic. This employs a unique cross-flow turbine. Australian Anthony Michell patented this invention in 1903. This recently rebuilt installation has a typical output of 3.3kW.
Paronella Park, Qld, 25kW.
Tinaroo Hydro Power station, Qld, 1.6MW.
Terminal Storage Mini Hydro on the Mannum/Adelaide pipeline, SA, 1.9MW.
Wellington Dam Hydro Power Station, WA, 2MW.
Arnold Power Station, NZ, 3MW.
Cardinia Dam Power Station, Vic, 3.5 MW.
Brown Mountain Power Station, NSW, 4.5MW.
Rowallan Power Station, Tas, 10.5MW.

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CLASSiC-DAC: a high-performance stereo digital-to-analog converter

Pt.1: By NICHOLAS VINEN

This high-performance stereo digital-to-analog converter (DAC) is based on the Cirrus Logic CS4398 as used in Marantz and other high-fidelity equipment. It has three TOSLINK inputs, three S/PDIF inputs, a USB audio input and offers playback from an SD card. As well, it has a built-in headphone amplifier, multiple status LEDs and fits in a compact low-profile case.

THE STEREO DAC project published in September, October and November 2009 has been a very popular project. In fact, several SILICON CHIP staff members subsequently built one and now use them on a regular basis.

Our new CLASSiC DAC supersedes that design and employs a better DAC chip, the Cirrus Logic CS4398, as used in the Crystal DAC upgrade (from February 2012). In addition, we have added many new features and obtained performance improvements.

First, the new unit (the CLASSiC DAC) is more compact than the original DAC at 225 x 165 x 40mm. It requires no mains wiring, being powered from an AC plugpack, drawing about 1.5W in standby mode and about 2.5W while running, so it's considerably more efficient than the earlier design.

The S/PDIF and TOSLINK inputs have been increased to three of each. And the addition of a USB type-B socket means that you can plug it straight into a computer or other USB audio device and play back audio at up to 48kHz/16-bit without the need for any additional hardware or drivers.

The addition of a high-quality headphone amplifier means that you can listen to the audio output. This, in combination with the ability to play

back WAV files from SD, SDHC or SDXC cards (up to 96kHz/24bit!), means that the CLASSiC DAC can be used as a self-contained music player.

In response to reader feedback, we've added sampling rate LEDs which indicate either 44.1kHz, 48kHz, 96kHz or 192kHz. There are also status LEDs for each input channel. These show the active channel and whether data is present on any of the other inputs.

Like our original DAC, this one also works with an infrared remote control but in addition to switching channels and changing volume, it can also be used to change tracks/folders when playing back from an SD card, put the unit into and out of standby (sleep) mode and perform other functions such as panning.

When playing back WAV files from an SD card, multiple directory levels are supported. There is also the option of using digital tone controls and a digital crossfeed circuit for when headphones are being used; these extra features work with sampling rates up to 48kHz.

A redesigned output filter offers slightly lower distortion than either of our previous DAC projects. Other features include click and pop suppression at power-up and power-down for the headphone amplifier and configurable gain to suit different headphone impedances. Automatic input scanning is also improved from the earlier design as this unit can sense the state of its inputs without having to switch to them.

Features & Specifications

- Three TOSLINK inputs, supporting 32-192kHz/16-24 bit (with appropriate receiver units)
- Three S/PDIF coax inputs, supporting 32-192kHz/16-24 bit
- USB audio input, supporting up to 48kHz/16 bit (no drivers required)
- SD card playback, supporting up to 96kHz/16-24 bit (MMC/SD/SDHC/SDXC)
- Programmable automatic input selection
- 2V RMS stereo line outputs
- Stereo headphone amplifier with volume control and click/pop suppression
- Supports 8-600Ω headphones
- Digital tone control and DSP headphone cross-feed (with SD card only, up to 48kHz)
- Infrared remote control
- Powered by 6-9VAC plugpack
- ~3W operating power, ~1.5W standby
- THD+N ~0.001% @ 1kHz (20Hz-20kHz bandwidth)
- Signal-to-noise ratio ~110dB
- Frequency response ±0.1dB 20Hz-20kHz
- Sampling rate indicator LEDs
- Input selection/status LEDs
- Standby/input cycle pushbutton & power indicator LED
- Fits in slim instrument case (225 x 165 x 40mm) with custom front & rear panels
- Most parts mount on a single PCB

Operation

Fig.1 shows a block diagram of the CLASSiC DAC. We are using a different digital audio receiver IC compared to our earlier DAC, a Crystal/Cirrus Logic CS8416. This is more expensive than the previously used DIR9001 but has more features which make the extra cost worthwhile. It has two internal 8-channel multiplexers and eight input amplifiers, so we don't need external amplifiers for S/PDIF inputs nor do we need an external multiplexer to select the active input.

Inputs 1-3 are TOSLINK optical inputs which use integrated fibre optic receiver units and these produce 3.3V or 5V square-wave outputs which are fed to three inputs on the CS8416 (IC1). The USB input is channel 4 and for this we use a PCM2902 IC (IC2) to do all the hard work of communicating with the host computer and implementing the USB audio protocol. This chip similarly has a 3.3V full-scale S/PDIF output which is fed to another of IC1's input channels.

The three coaxial S/PDIF inputs

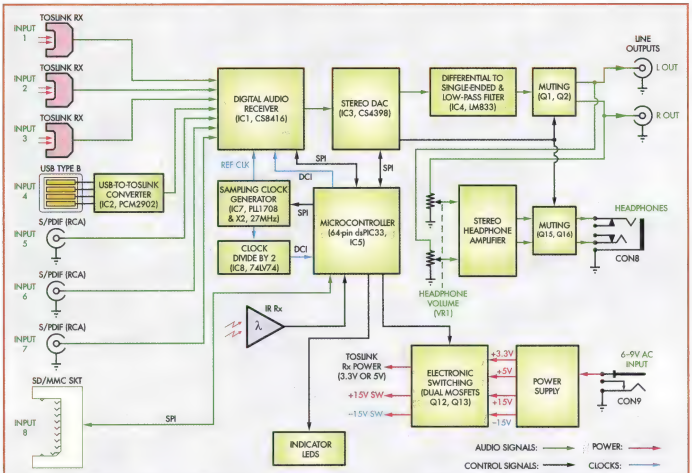


Fig.1: block diagram of the CLASSiC DAC. Its main components are the CS8416 digital audio receiver (IC1), a CS4398 stereo DAC (IC3), a PLL1708 clock generator (IC7) and a dsPIC33 digital signal controller/microcontroller (IC5). The eight inputs are shown at left, while the line and headphone outputs are at right.

use RCA sockets which are connected straight into three more of IC1's input channels. Coaxial S/PDIF signals can have quite low amplitude so in this case, IC1's internal amplifiers are required to boost the signal level high enough to allow its decoding circuitry to handle them.

IC1's eighth and last input is used to feed it audio when playing back WAV files from an SD card. The actual SD card reading is handled by microcontroller IC5 (a dsPIC33) and this then converts the WAV audio data to an S/PDIF stream which it feeds to IC1. This means that IC5 does not need to interface with the DAC directly and avoids the need for additional signal multiplexing.

Once IC1 has selected and amplified the selected input signal, it then decodes the S/PDIF data and analyses it in a number of ways. Its most important task though is to extract the audio content and output it serially via an I^2S (inter-IC sound) bus which is connected to the CS4398 DAC (IC3).

IC3 converts the digital audio stream to a pair of analog signals which are fed to a low-pass filter. This converts the pairs of differential outputs from IC3 into the more typical single-ended analog outputs used by most amplifiers and other pieces of audio gear.

New DAC filter

We have made some changes to the filtering network in order to improve its performance. The filter used in the Crystal DAC design (February 2012), also based on the CS4398 DAC IC, used the suggested filter from the Cirrus Logic data sheet but we had rounded some of the odd component values (eg, 698Ω) to the nearest E24 series value, such as 680Ω. However we have subsequently discovered, via SPICE simulations, that even this slight shift in component values seriously degrades the ability of the filter to reject common mode signals.

Obviously, the actual components won't have the exact value printed on them so to some extent any actual filter is going to deviate from the ideal but we figure that if the filter can be shown to work effectively with exact values, it should at least perform reasonably well with real components, especially considering that 1% resistors are often much closer than 1%. Capacitors are another matter but 5% MKT types are not difficult to get and 2.5% or better are available.

So we again fired up SPICE ("Simulation Program with Integrated Circuit Emphasis"). Using this software, we came up with a filter arrangement that uses only E24-series values for resistors and E12-series values for capacitors and provides (in theory at least) even better common mode signal rejection than the suggested filter in the data sheet and with a flatter frequency response, when the whole circuit is taken into account.

This new filter arrangement is shown in Fig.2. Fig.3 compares its

frequency response and CMRR (common mode rejection ratio) to that of the filter as specified in the Cirrus Logic data sheet (with the unreal component values) and the filter with rounded values, as used in the Crystal DAC.

Note that we have gone back to using an LM833 dual low noise op amp rather than discrete component circuitry for the audio output filters, as used in the Crystal DAC. This was to reduce the size and complexity of the overall circuit as it would otherwise be over the top.

Muting & output

The CS4398 supports using transistors to mute the outputs when they are idle or muted, to suppress clicks and pops. We used this feature in the Crystal DAC but we decided to use back-to-back Mosfets rather than special bipolar junction transistors as they are easier to get. We are again using this arrangement, also shown in Fig.2. However, because we have designed the DAC to use the CS4398 from the start, this unit has superior control over the muting FETs and so suppresses clicks and pops more effectively.

The line outputs of the unit are taken from the outputs of the DAC filters, at the point where the muting FETs connect. These signals are also fed to the dual-gang volume control pot for the headphone amplifier.

The headphone amplifier is a current-boosted op amp arrangement, reminiscent of Peter Smith's November 2005 design although we actually redesigned it from scratch. It's based on another LM833 and while the performance is not quite as good as the discrete HiFi Stereo Headphone Amplifier circuit published in the September and October 2011 issues, it is still of a very high standard and well above that available from the headphone sockets of most CD players. Again, this was done to keep the overall complexity and size of the unit within reason.

The gain is normally set at unity (ie, 0dB) using a pair of jumpers and this suits 8-60Ω headphones, giving an undistorted power output of around 100mW across this impedance range.

For higher impedance headphones, 12dB of gain can be selected, giving around 100mW into 600Ω. Lower impedance headphones can also be used in combination with this gain but the result will be slightly more noise, possibly audible as hiss when no signal is present, depending upon the sensitivity of the headphones used.

The output is via a 6.35mm stereo jack socket and the headphone amplifier is designed to endure a continuous short circuit, although typically the output is only shorted briefly when the headphone jack is inserted or removed.

A second set of muting FETs are connected across the headphone outputs, as with the line outputs. This is designed to prevent the headphone amplifier output from causing a loud

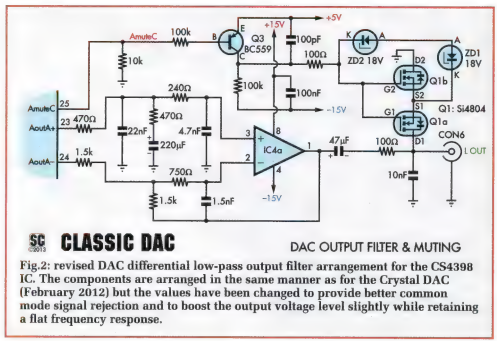


Fig.2: revised DAC differential low-pass output filter arrangement for the CS4398 IC. The components are arranged in the same manner as for the Crystal DAC (February 2012) but the values have been changed to provide better common mode signal rejection and to boost the output voltage level slightly while retaining a flat frequency response.

Why Build This High-Performance DAC?

IF YOU ALREADY own a DVD player of average quality or better, you can hook it up to this DAC and immediately upgrade the sound quality. Most DVD players have mediocre audio quality from their audio outputs, especially in terms of distortion (see "DVD Players: How Good Are They For HiFi Audio?" – SILICON CHIP, October 2007). Some CD players can also have their performance improved with the addition of this DAC, provided of course that the CD player in question has a TOSLINK or S/PDIF digital output.

So why are typical DVD players so poor in audio performance? Partly it is because they are designed down to a very low price and while their on-board DAC might be quite a reasonable component, the supporting circuitry has been cut to the bone in order to keep the overall price as low as possible. It is also true that many cheap (and not so cheap) DVD players are plagued with quite strong extraneous RF in the audio outputs, mainly related to the video output signals that they continuously produce, regardless of whether they are playing DVDs or CDs.

In addition, virtually all DVD players, except the most expensive models, use switchmode power supplies. These have the advantage of being very efficient and especially with respect to recent models, have very low standby power consumption. The drawback of switchmode power supplies is that they produce lots of switching harmonics which can get into the audio outputs.

Finally, because all DVD players these days are double-insulated and come with 2-core power cords, they inevitably cause hum and buzz when connected to the audio inputs of high-fidelity amplifiers which are usually earthed via a 3-core mains cord. There is no simple way to fix any of these problems but this new DAC project fixes them all and provides first-class audio performance.

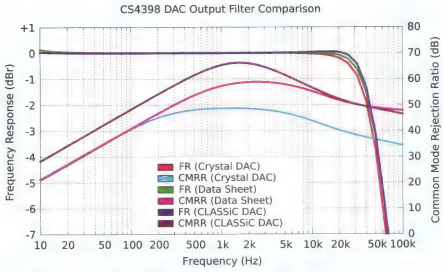


Fig.3: comparison of the frequency response and common mode rejection ratio (CMRR) of the various filter arrangements. This includes that of the Crystal DAC (using standard component values), that from the CS4398 data sheet (using non-realistic component values) and the revised standard values used in the CLASSiC DAC. The CMRR has been improved by about 18dB @ 1kHz.

thump in the headphones when power is applied or removed, due to various capacitors charging up. This works in combination with the electronic power supply switching arrangement, shown at the bottom of the block diagram.

When power is first applied, the ±15V rails are switched off and it is these rails that power the op amps in both the DAC filter and headphone amplifier, as well as the current-boost transistors in the latter. This gives the muting FETs time to switch on first, after which the ±15V rails are brought up. Once the amplifier has stabilised, the FETs are switched off and the DAC can then be enabled to drive the headphones.

A similar procedure is used during switch-off but in reverse, ie, the muting FETs are switched on and the ±15V rails are switched off before the supply collapses entirely.

WAV playback

While we mentioned this capability earlier, here are some more details on WAV file playback. Note the clock generation section shown in Fig.1, to the left of microcontroller IC5. When reading a WAV file from the SD card, the micro determines the sampling rate used from the file header and must generate a matching clock, both to time the data transfer to the DAC IC and also for the DAC IC to use to reproduce the analog audio.

A PLL1708 audio clock generator (IC7) is used for this purpose. It uses a 27MHz crystal and an internal PLL (phase locked loop) to generate all the common audio sampling rates, from 16kHz to 96kHz, with nine different options. It outputs up to four different clocks which are multiples of these rates, at 256, 384, 512 or 768 times.

For WAV playback, to generate the required S/PDIF serial stream to send to the digital audio receiver, we need a clock that's 128 times the sampling rate. So we take the 256x sampling rate output from IC7 and divide it by two using a low-voltage, high-speed

What Are S/PDIF And Toslink?

The acronym S/PDIF (or SPDIF) stands for Sony/Philips Digital Interface. Basically, it is a standardised serial interface for transferring digital audio data between consumer-level equipment such as DVD and CD players, DAT and DVD recorders, surround-sound decoders and home-theatre amplifiers.

S/PDIF is very similar to the AES3 serial digital interface used in professional recording and broadcasting environments. In operation, each digital audio sample (16-24 bits) is packaged along with status, control and error-checking information into a 32-bit binary word. This is then modulated or encoded into a serial bitstream using the Biphase Mark Code (BMC).

BMC involves combining the data bits with a clock signal of twice the data bit rate, in such a way that a binary "1" results in two polarity reversals in one bit period, while a binary "0" results in a single polarity reversal. This double bit-rate signal is self-clocking at the receiving end and has no DC component.

The BMC encoded serial bitstream is then transmitted as a 400mV peak-to-peak signal along a single 75-ohm coaxial cable. In most cases, the cable connectors used are standard RCA or "Cinch" connectors, as also used for analog audio and composite video.

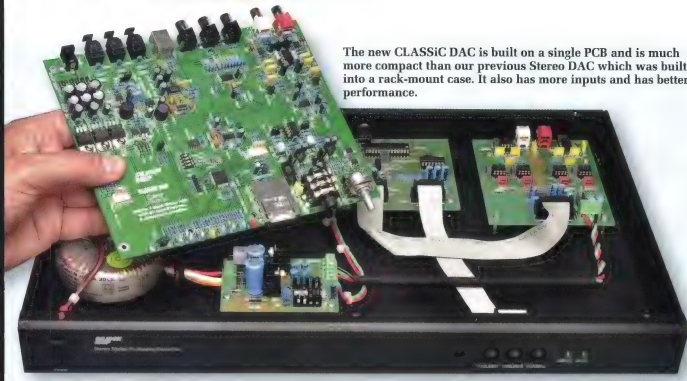
Although originally developed for conveying linear PCM (LPCM) digital audio signals as used in CD and DAT audio, S/PDIF has also been adapted for conveying compressed digital audio, including Dolby Digital (AC-3), DTS and MPEG-2 audio.

TOSLINK is essentially just the S/PDIF signal format converted into the optical domain, for transfer along optical-fibre cables. The accompanying table (see above) shows the most common domestic audio bitstream formats and the S/PDIF/TOSLINK bit rates for each one. Note that LPCM audio is rarely used for DVD-Video, because even a stereo audio track requires a BMC bit rate of 6.1Mb/s.

Many current-model DVD players and recorders are provided with either coaxial S/PDIF or TOSLINK digital audio inputs and outputs, or quite often a mixture of both. Similarly, many home-theatre amplifiers are provided with coaxial S/PDIF and/or TOSLINK inputs. This is also the case with many up-market PC sound cards.

Digital Audio Bitstream Formats

SOURCE & CODING	CD-Audio (LPCM)	DVD-Video & DAT (LPCM)	DVD-Audio (LPCM)		DOLBY DIGITAL (AC-3 COMPRESSED)
			96kHz	192kHz	
SAMPLING RATE	44.1kS/s	48kS/s	96kS/s	192kS/s	48kS/s
MAX DATA BIT RATE	2822kb/s	3072kb/s	6144kb/s	12.288Mb/s	448kb/s
SPDIF (TOSlink) BMC BIT RATE	5644kb/s	6144kb/s	12.288Mb/s	24.576Mb/s	896kb/s



The new CLASSiC DAC is built on a single PCB and is much more compact than our previous Stereo DAC which was built into a rack-mount case. It also has more inputs and has better performance.

flipflop (IC8). This is then used to clock the dsPIC33's Data Converter Interface (DCI). The micro selects the clock speed for the required sampling rate by sending commands to the PLL1708 using an SPI (Serial Peripheral Interface) bus.

We also send the 256x (undivided) clock to the CS8416 digital audio receiver (IC1). This is used as a reference clock, when one of the other seven inputs is selected. The CS8416 contains circuitry to measure the ratio of the sampling rate of the incoming audio stream to the reference clock. Thus, by setting a known clock rate output from the PLL1708 and reading the control registers from the CS8416, the micro is able to accurately determine the incoming audio sampling rate and then displays it using the four LEDs.

Control & user interface

Besides the aforementioned infrared remote control and headphone volume control, the only other control input on the CLASSiC DAC is an illuminated pushbutton. This can be used to cycle through the inputs and switch the unit into and out of standby mode. The button is brightly illuminated when the unit is on and dim when the unit is powered but in standby.

The rear panel carries the power input socket, seven digital audio inputs and two line outputs. The front panel has the headphone amplifier volume control, headphone socket, power switch/LED, SD card socket and 12 status LEDs.

Power supply

The power supply for the original SILICON CHIP DAC was purely linear, with an 18V-0-18V toroidal transformer, full-wave rectifier, filter capacitors and linear regulators. This worked well but was quite inefficient, with the unit consuming 6-8W and the case lid above the power supply PCB becoming slightly warm during operation.

To make the power supply more efficient and to allow the use of a common type of AC plugpack, the CLASSiC DAC power supply is a bit more complicated. The ±15V rails are derived using linear regulators but their input voltage is boosted using two full-wave voltage doublers. These rails are also switched off in standby mode, as the doubler greatly decreases the supply efficiency for these rails.

This arrangement means that the rectified and filtered supply from which the lower voltage rails (5V & 3.3V) are derived is substantially lower and so no dropper resistor is required, with its inherent inefficiency. Also, for the 3.3V rail, from which substantial current is drawn during operation (for the micro and some of the other ICs), a switch-mode buck pre-regulator is used, to drop the 10V or so input to 3.9V with high efficiency (90+%).

The 3.9V output of this switchmode regulator is then regulated to 3.3V using a linear regulator as the switchmode regulator has relatively poor ripple rejection and the CS8416 digital audio receiver IC requires a clean 3.3V rail for its PLL to operate properly and provide a low-distortion audio output. There are also several LC (inductor/capacitor) filters in the power supply to further reduce switchmode noise, so it won't affect analog audio performance.

Since much less current is required on the 5V rail, this is derived using a 7805 linear regulator. The TOSLINK receivers operate from either the 3.3V or 5V rail, depending on which type are used, and these draw power while ever their supply is present. So to save power during standby, the supply for these units is also turned off using a Mosfet.

All linear regulators use the PCB as a heatsink. Total dissipation is about 3W, spread across about 10 devices (regulators and ICs), so the copper on the PCB (and to a lesser extent, the fibreglass) is more than adequate to spread and radiate the waste heat. In operation, the case only gets slightly warm, directly above the power supply section (rear left corner).

What's coming

Next month, we'll present the full circuit details for the CLASSiC DAC and publish several graphs showing its audio performance. A final article will then describe the construction, testing and set-up. SC

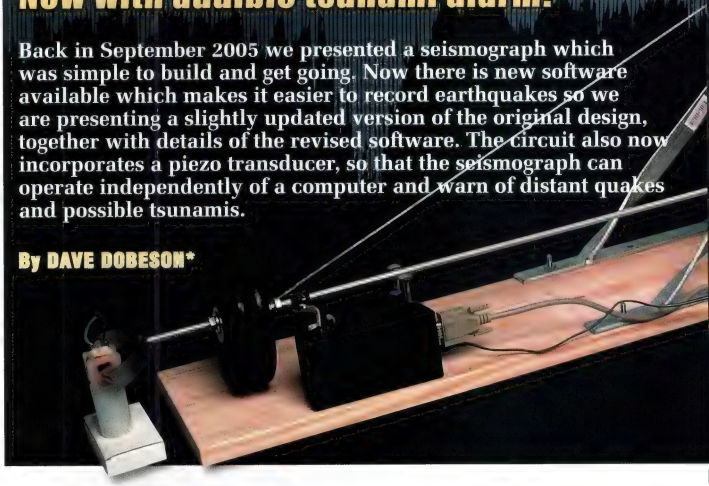
Build your own . . .

Seismograph

Now with audible tsunami alarm!

Back in September 2005 we presented a seismograph which was simple to build and get going. Now there is new software available which makes it easier to record earthquakes so we are presenting a slightly updated version of the original design, together with details of the revised software. The circuit also now incorporates a piezo transducer, so that the seismograph can operate independently of a computer and warn of distant quakes and possible tsunamis.

By DAVE DOBESON*



AUSTRALIANS can be thankful that we are not normally affected by the large earthquakes and volcanoes that regularly devastate so many other parts of the world. But if you travel overseas you soon become aware of just how destructive they are and their dramatic effect on the countries concerned. Add in the wholesale destruction and loss of life due to tsunamis and it is not surprising that there is continuing interest in making a seismograph.

About The Author*

Dave Dobeson (ddobeson@bigpond.net.au) is a science teacher at Turramurra High School and the University of Sydney Science Teacher Fellowship holder for 2005.

Designed for schools

This simple seismograph was originally described in "Scientific American" in 1979 and has been adapted for science teachers to build and use in the school laboratory – see **http://science.uniserve.edu.au/school/Seismograph**

Movements of the seismograph, which is basically a horizontal pendulum, are detected using a simple light sensor circuit. In operation, a metal vane attached to one end of the pendulum (or bar) partially blocks the light between a LED and an LDR (light-dependent resistor). However, when the room moves (ie, during an earthquake), the amount of light falling on the LDR is modulated by the metal vane.

The unit described here is known as a "Lehman" or "Horizontal Pen-

The mechanical section of the seismograph uses parts that are readily available from a hardware store. It's based on a swinging horizontal pendulum and movement is detected using a vane and light sensor circuit mounted at one end.

dulum" seismograph. It's also called a "Swinging Gate Seismograph", because the bar and its supporting wire look like an old-fashioned farm gate. The "hinges" (actually the pivot points) of the "gate" are not quite vertically aligned, with the top hinge just forward of the bottom hinge so that the "gate" will swing shut. In practice, this means that the horizontal pendulum (or bar) swings slowly back to its original resting position

The signal produced by the LDR is fed to an inverting op amp stage and this drives a PICAXE-08M microcontroller which functions as an analog-to-digital converter. You can feed the resulting data to a computer to store, display and print the results.

AmaSeis

The original seismograph used PC software called StampPlot Lite to plot the results but it required several steps to see the output over more than a few hours.

Since then, I have discovered "AmaSeis" (see **http://pods.binghamton.edu/~ajones/AmaSeis.html**) which is an excellent freeware program for use with amateur-built seismographs. Written by Alan Jones, it can accept the digital output from a number of commercial ADCs and display it as a 24-hour helical drum recording, just like professional seismographs (more on AmaSeis later).

Building the seismograph

OK, let's take a look at the mechanical details of our seismograph. The basic set-up comprises an 800mm-long 5/16-inch threaded steel rod that's fitted with a 2-3kg mass at one end. The other end of the rod is ground to an edge and pivots on the end of a ½-inch bolt – this forms the lower pivot point. The supporting wire is attached to the rod at one end, just before the weights, and to a turnbuckle at the other end. This then pivots about 25-30cm above the lower pivot.

If we align the seismograph pivots so that the top pivot is less than 1mm forward of the bottom pivot, then the seismograph bar will always swing back to its central position and will have a natural period of about 5-10 seconds. However, if the pivots are exactly vertically aligned, there will be no restoring force and it will never swing back. We cannot move the top pivot too far forward though, otherwise the seismograph will be less sensitive.

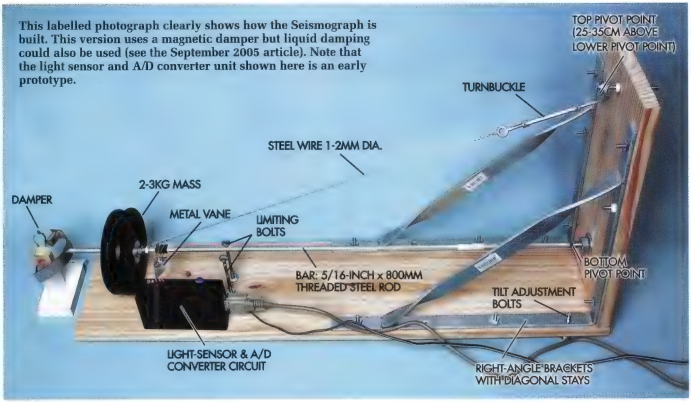
This unit is very sensitive to the mostly horizontal motion of earthquake "L-waves" but is insensitive to "P-waves" which are mostly vertical. Kiwis, because they are much closer to the action, might be able to detect P-waves if they use a spring instead of the wire and cut the end of the metal vane at 60°. Perth, Tennant Creek and Yass also have small local quakes every few months, so you might like to experiment with a spring support system if you live in these areas.

The hook at the end of the turnbuckle sits in a 5mm dimple that's drilled into a large washer. This assembly forms the top pivot point.

This alternative scheme for the top pivot point is an improvement on the original scheme. In this case, the hook sits in a dimple drilled into the end of a metal lever. The lever allows fine adjustment of the horizontal position of the turnbuckle hook and eliminates the need for tilt adjustment bolts (so the seismograph can now sit flat on its base).

By the way, it's important to remember that although we often talk about the bar (or pendulum) of the seismograph "swinging", it's really the room that moves during an earthquake. The bar, because of the inertia of a heavy mass attached to one end, initially stays still. In effect, the unit and its associated logger act as a low-pass filter which renders the unit insensitive to everyday events (footsteps, doors closing, passing traffic, etc).

The accompanying photos show



This labelled photograph clearly shows how the Seismograph is built. This version uses a magnetic damper but liquid damping could also be used (see the September 2005 article). Note that the light sensor and A/D converter unit shown here is an early prototype.

most of the construction details. **The only critical dimension is that the top pivot must be less than 1mm in front of the lower pivot.** As well as the wooden frame shown, the unit could be built into any strong cupboard, bookcase, shelf or even a strong metal frame. In that case, the brackets and wooden frame would not be needed. Any type of metal rod could be used (as long as it's strong enough) and the same goes for the mass at one end.

Note that you will have to "re-zero" the seismograph for the first few weeks after building it, as the wire, brackets and wood flex under the strain. After that, it will be a matter of making routine adjustments every few months.

Top pivot point

The top "hinge" (or pivot point) is made by drilling a 5mm diameter hole about half-way through the outer section of a large, thick washer or through a flat metal lever, ie, to make a "dimple". Small washers and a nut are used to hold the large washer or lever in position, while a nut and lockwasher behind the wooden upright panel lock the bolt in place.

As shown in the photos, the hook at the end of the turnbuckle sits in the dimple, so that it can freely pivot. In operation, the turnbuckle adjusts the tilt of the bar and is set so that the bar is horizontal. The securing bolt can be screwed in or out to move the top pivot point relative to the bottom pivot.

This is important for the overall functioning of the seismograph because it affects the natural period of the bar (ie, the time for one complete swing

This view shows the magnetic damping arrangement fitted to the prototype seismograph. It uses a couple of super magnets, a U-bracket and a large coil of wire with the ends joined.

A better magnetic damping scheme involves using a single super magnet which moves inside a large coil of enamelled wire wound on a bobbin salvaged from plumber's tape.

from the centre to one side, then back through the centre to the other side and finally back to the centre again).

A period of about five seconds seems to work best for the author's seismographs in Sydney.

Note that the lever option is the better of the two schemes. It allows the horizontal position of the turnbuckle hook to be finely adjusted and so eliminates the need for tilt adjustment bolts (so the seismograph can sit flat on its base).

The pivot end of the 5/16-inch threaded rod is ground to a knife-edge and this sits against the end of a ½-inch bolt. Wind a nut onto the rod before you cut and grind it, so that the thread is restored when the nut is removed. Be sure to use safety goggles when drilling, cutting or grinding metals – you only have one pair of eyes.

Mounting point alignment

In order for the seismograph to work correctly, the lower mounting point must be directly below the upper mounting point. The best way to ensure this is to use a plum-bob made from fine fishing line and a lead sinker.

The two rear-most vertical bolts that go through the support brackets are used for tilt adjustment – see photo. These both screw into threads that are tapped through the wooden base and the brackets (nuts under the wooden base will do) and each has a screwdriver slot cut into its end. This allows you to use a screwdriver to tilt the seismograph sideways and forwards or backwards, to alter the position of the bar and thus its period and sensitivity.

As stated above though, tilt adjustment is unnecessary if you use the lever method for the top mounting point.

The far end of the seismograph wooden frame has a single central support. A sheet of plywood or particleboard underneath will stop the three supports from sinking into the carpet when the unit is positioned on the floor.

Swinging the weight

Just about any mass of 2-3kg will provide sufficient inertia to initially keep the bar still during an earthquake, provided it doesn't hang too far below the bar. A pair of 1.25kg barbell weights are ideal for the job. They cost just a few dollars each from a sports store and come with a ready-made hole

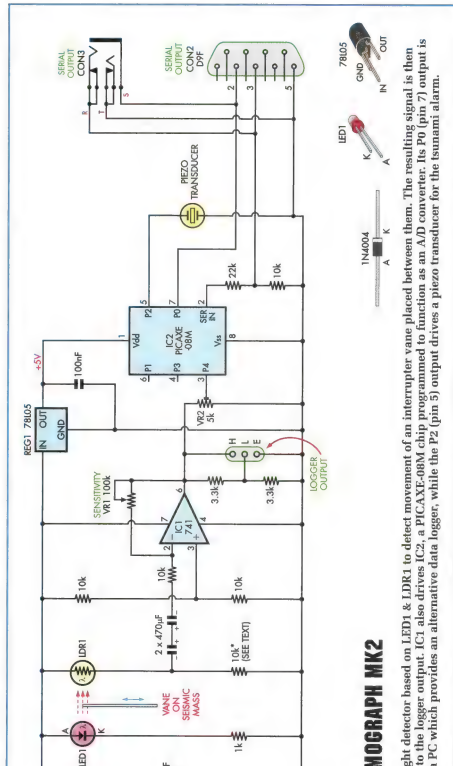


Fig.1: the circuit uses a light detector based on LED1 & LDR1 to detect movement of an interrupter vane placed between them. The resulting signal is then amplified by IC1 and fed to the logger output. IC1 also drives IC2, a PICAXE-08M chip programmed to function as an A/D converter. Its P0 (pin 7) output is fed to the serial input of a PC which provides an alternative data logger, while the P2 (pin 5) output drives a piezo transducer for the tsunami alarm.

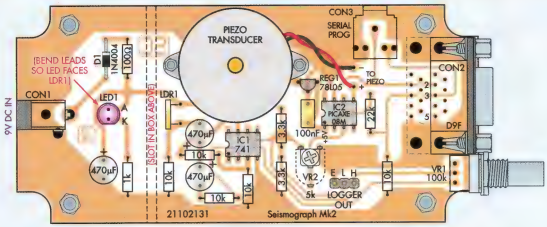


Fig.2: install the parts on the PCB as shown here, making sure that all polarised parts are correctly orientated. IC2, REG1, VR2 and CON2 can be left out if you already have an external data logger and don't intend using a PC.

through the middle. This means they can be simply slipped over the end of the bar and clamped in position using nuts and washers on either side.

Damping

Once earthquake waves set the bar swinging, it will keep swinging for hours unless it is damped. Perfect damping would stop the bar after a few swings but in practice, under 2-3 minutes is OK.

You can use either magnetic or liquid damping but magnetic damping is the more consistent. Magnetic damping involves attaching one or two super magnets to the end of the bar. A coil of wire with the ends joined is then placed in the magnetic field.

When the bar moves (ie, during an earthquake), current is induced into the wire coil. This in turn produces a magnetic field that counters the magnet(s) and damps the motion of the bar.

The accompanying photos show two alternative schemes. The best scheme is to use a single super magnet which moves inside a large coil wound on a plastic bobbin salvaged from "plumber's tape" (this will damp the seismograph in about one minute). Just wind on as many turns of 0.71mm-diameter enamelled copper wire as you can and don't forget to join the ends of the coil.

The super magnet is attached to the threaded rod using Liquid Nails® or similar adhesive.

Positioning the seismograph

The ideal location for your seismograph is on a concrete block that's set into bedrock at the bottom of a sealed mine shaft! If you don't have access to a mine shaft(!), the seismograph should be installed in a closed room or cupboard, or in a strong bookcase surrounded by a Perspex cover (to prevent air movement over the unit).

This is important because it is the location of the seismograph and the vibrations and mechanical "noise" around it that determine its ultimate sensitivity.

Detector circuit details

Fig.1 shows the detector circuit. Power comes from a 9V DC plugpack supply, with D1 providing reverse polarity protection. The associated 100Ω resistor and 470µF capacitor provide supply decoupling and ripple filtering.

The filtered DC rail is used to power LED1 via a 1kΩ current limiting resistor. The LDR and its associated 10kΩ resistor effectively form a voltage divider across this supply rail, the voltage at their junction varying according to the resistance of the LDR. This in turn depends on the amount of light reaching it from the LED.

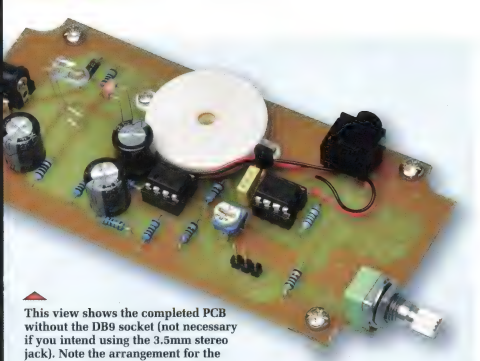
The output from the LDR is fed to the inverting (pin 2) input of op amp IC1 (741) via two back-to-back 470µF capacitors. These capacitors block the DC component at the output of the LDR while allowing signal fluctuations to be fed to the op amp. They also block any slow variations in the LDR signal due to thermal variations in the room.

IC1 functions as an inverting amplifier stage and its gain can be varied from 0-10 using potentiometer VR1, which is in the feedback loop. IC1's output at pin 6 is fed to a voltage divider consisting of two 3.3kΩ resistors. The top of this divider (ie, at pin 6) can be used to directly drive an external data logger. Alternatively, the divider output (at the junction of the resistors) can be used to provide a nominal 0-5V signal, which may be required by some loggers.

Pin 6 of IC1 also drives trimpot VR2 and this is used to set the maximum signal level into pin 3 of IC2, a

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	22kΩ	red red orange brown	red red black red brown
❑	4	10kΩ	brown black orange brown	brown black black red brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown



This view shows the completed PCB without the DB9 socket (not necessary if you intend using the 3.5mm stereo jack). Note the arrangement for the LED & the LDR.

PICAXE-08M or PICAXE-08M2. IC2 is programmed to function as an analog-to-digital (A/D) converter. Its serial data output is taken from pin 7 (P0) and fed to pin 2 of DB9F socket CON2.

This socket is in turn connected to the serial port of a PC, to provide the alternative data logger. Of course, most PCs these days don't have a RS232 serial interface but you can jump this hurdle by using a USB-to-serial interface cable to make the connection.

As a result, this Mk.2 version of the circuit also includes a 3.5mm stereo jack socket (CON3) in parallel with the DB9F socket, with the P0 output from IC2 going to the sleeve (S). This allows the circuit to be connected to the PC via an AXE027 PICAXE USB Download Cable (from Revolution Education). This cable has a USB connector at one end and a 3.5mm stereo jack plug at the other (instead of a DB9M connector).

The PICAXE-08M is programmed via pin 3 of CON2 or via the ring (R) of CON3. The incoming data is fed to pin 2 (SER IN) of IC2 via a voltage divider consisting of 22kΩ and 10kΩ resistors.

The other important change to the original circuit involves the addition of a piezo transducer which is driven by the P2 output (pin 5) of IC2. Hence if an earthquake is detected, the piezo transducer will immediately sound.

Power for IC2 is supplied via 3-terminal regulator REG1 which provides a regulated +5V rail to pin 1.

PCB assembly

Building the unit is easy since all the parts are mounted on a small PCB coded 21102131. Fig.2 shows the assembly details.

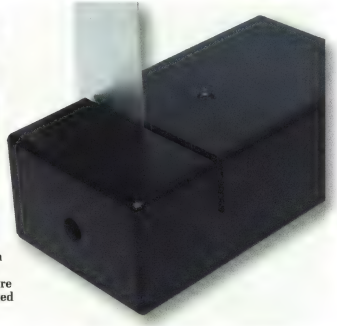
Note that REG1 and the PICAXE (IC2) are not needed if you propose to use an external data logger (and don't need the audible alarm). If so, these parts can simply be left out, along with the DB9F socket CON2, CON3, trimpot VR2, the 100nF capacitor and the 22kΩ and 10kΩ voltage divider resistors from pin 2 of IC2.

On the other hand, if you want to have the piezo transducer, you need REG1, IC2 and their associated parts.

Follow Fig.2 to install the parts on the PCB, making sure that all polarised parts are correctly orientated. IC1 & IC2 are fitted using sockets but don't plug the ICs in yet – that step comes later.

Note that the 10kΩ resistor shown in series with the LDR on Fig.1 is correct for most LDRs. However, some LDRs have a lower resistance than others in the presence of light and you may have to adjust the value of the 10kΩ series resistor accordingly.

To do this, just measure the resistance of the LDR when it is fully lit by



In the prototype, the LED & the LDR were brought out through holes in the case, with the seismograph's vane sitting between them – see above. In the final version (right), the LED & LDR are inside the case and the vane rides in a slot. The vane is adjusted so that it normally "shadows" about half the LED body.

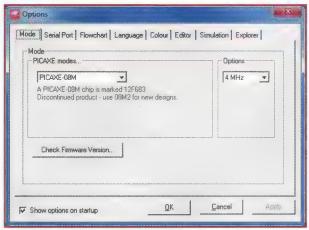


Fig.3: before programming the PICAXE, you first have to select the device to be programmed in the PICAXE Programming Editor.

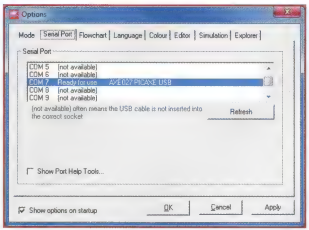


Fig.4: the COM port that the detector PCB is connected to is selected using this dialog box. Here, the AXE027 cable is being used and the relevant port is COM7.

the LED in a dark room and select a series resistor that's about the same value.

Checks & adjustments

Before fitting the ICs, it's necessary to make several voltage checks. First, connect a 9V DC plugpack supply and switch on. The LED should immediately come on. If necessary, adjust it so that it shines directly on the LDR.

Next, use a digital multimeter to check the voltages on IC1's socket pins. Pin 7 should be at the supply voltage (about 9V, depending on the plugpack), pin 2 should change when the light to the LDR is suddenly interrupted and pin 3 should be at half supply voltage. That done, check for +5V on pin 1 of IC2's socket and for 0V on pins 2, 3, 7 & 8.

If it all checks out so far, disconnect the plugpack and install IC1 (but not IC2). You now have to adjust trimpot VR2 so that the voltage on pin 3 of IC2 can never exceed 5V. This is done as follows:

(1) Connect a clip lead across the two back-to-back 470µF capacitors (ie, short them out).

(2) Set VR1 & VR2 to their mid-range positions.

(3) Place a piece of thick cardboard between the LED and the LDR to block the light.

(4) Reapply power and check the voltage at pin 6 of IC1. It should be about 1V less than the supply rail.

(5) Monitor the voltage at pin 3 of IC2's socket and adjust VR2 for a reading of 4V (or slightly less).

Once that's done, disconnect the plugpack and install the PICAXE-08M, with its notch facing to the left – see Fig.2.

Final assembly

The PCB is designed to fit inside a standard UB3 utility case. It's mounted on the lid on four 9mm untapped spacers and secured using M3 x 15mm screws and nuts.

That done, you have to make a cut-out in one end of the case to provide clearance for the DB9F socket (CON2) and the pot shaft. This cut-out measures 45mm long x 12mm high and is about 12mm from the lip of the base. You will also need a hole in the side of the case to access CON3.

You also need a hole directly in-line with the DC power socket (CON1). This is horizontally centred 17mm

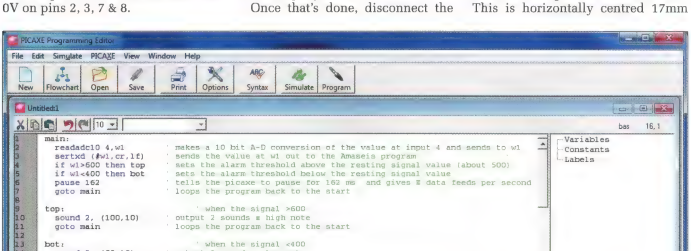


Fig.5: this dialog shows the main window of the PIXAXE Programming Editor after opening the software file. Clicking the Program button then downloads the software into the PICAXE (IC2). Don't forget to adjust the alarm thresholds (see text).

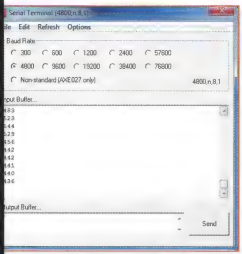


Fig.6: use the Terminal dialog to check that the baud rate for the transmitted data is 4800.

from the lip of the case and should be drilled and reamed to 8mm.

Finally, a slot must be cut in the case in line with the light sensor to provide access for the vane that's attached to the bar. This slot should be positioned 37mm from the end of the case and can be about 4mm wide. The unit can then be assembled into the case and attached to the base of the seismograph.

Position the vane so that it normally blocks about half the light between the LED and the LDR.

Note: if you are using the seismograph for demonstration purposes, leave the cover off the utility box. This will let people can see how the vane partially blocks the light beam and lets them monitor how the on-screen display and the alarm respond to movement (the seismograph will, however, be sensitive to rapid changes in light level).

Audible alarm

How effective is the piezo transducer in sounding the alarm? Well, a recent magnitude 6.6 quake near Vanuatu (October 21, 2012) triggered the alarm for about five minutes while a larger 7.3 earthquake in the Banda Sea (near Indonesia) on December 11, 2012 set the transducer going for more than 30 minutes until the wave sequence had passed through Sydney (see Fig.7). The alarm woke me up but Berowra (just to the north of Sydney) is hardly likely to be affected by tsunamis so I did not bother to evacuate!

In any case, the quake took place 150km down in the subduction zone, so there was no damage or tsunami reported. If you want to find out more, you can go online to Geoscience Australia to find the epicentre and read the tsunami warnings.

Those who do live in areas at risk from tsunamis would get plenty of advance warning if the alarm sounded. That's because earthquake waves travel more than 50 times faster than the tsunami waves, so there's usually plenty of time to get to higher ground.

Programming the PICAXE

Of course, as well as adding the piezo transducer, you also have to reprogram the PICAXE-08M so that can drive the transducer (as well as correctly interact with AmaSeis). To do that, you need to first download and install the *PICAXE Programming Editor* on your PC. It's available for free from **www.PICAXE.com/Software**

While you're there, you should also grab the *AXE027 USB Cable Driver* (but only if you intend using the AXE027 PICAXE USB Download Cable from Revolution Education).

Once the *PICAXE Programming Editor* software has been installed, switch off and connect the detector PCB to the PC. If you are using an old PC that has serial ports, this can be done using a standard serial cable (eg, scrounged from an old modem).

If your PC doesn't have a serial port, then you will have to use a USB-to-

Parts List: Seismograph Detector

1 PCB, code 21102131, 123 x 57mm
1 9V DC plugpack
1 piezo transducer (Jaycar AB-3440, Altronics S-6140)
1 2.1mm DC power socket (CON1)
1 DB9F connector (PC-mount) or 3.5mm stereo jack socket (Altronics P-0094)
1 plastic utility box, 130 x 67 x 44mm
4 9mm-long untapped spacers
4 M3 x 15mm machine screws
4 M3 nuts
1 serial computer cable or USB-to-serial cable (see text)
2 8-pin IC sockets
1 100kΩ linear potentiometer (VR1) (Jaycar RP-8518)
1 5kΩ horizontal trimpot (VR2)
1 Light Dependent Resistor (LDR1)
1 3-way pin header
2 M2.5 x 6mm machine screws & nuts (to secure transducer)

Semiconductors

1 741 or OP27 op amp (IC1)
1 PICAXE-08M or PICAXE-08M2 microcontroller (IC2)
1 78L05 3-terminal regulator (REG1)
1 1N4004 diode (D1)
1 red or white high-brightness LED (LED1)

Capacitors

3 470µF 25V electrolytic
1 100nF MKT (code 104 or 100n)

Resistors (0.25W, 1%)

1 22kΩ
4 10kΩ
2 3.3kΩ
1 1kΩ
1 100Ω
1 x 10kΩ or 1 x 3.3kΩ or 1 x 1kΩ resistor to match LDR resistance – see text

Mechanical Parts

1 800mm-long x 5/16-inch threaded steel rod
5 5/16-inch nuts and washers to suit rod
1 50mm-long x 1/4-inch bolt
3 1/4-inch nuts and washers
1 40mm-long x 1/2-inch bolt
1 1/2-inch nut and washers
1 3/8-inch washer
1 1-metre length 1-2mm diameter steel wire
1 2-2.5kg mass (eg, 2 x 1.25kg barbell weights)
1 piece of thin aluminium sheet (to make vane to interrupt light beam)
1 bulldog clip (to attach metal vane to threaded rod)
1 or 2 super magnets
1 metal bracket to carry magnets (see text)
1 coil with shorted ends (see text)
2 braced right-angle brackets, 250 x 250mm
8 1/4-inch x 40mm bolts, nuts & washers
3 5/16-inch x 100mm round-head bolts, nuts & washers
1 wooden base, 900 x 250 x 20mm
1 wooden back, 400 x 250 x 20mm

Note: the PCB can be obtained from Silicon Chip PartShop.

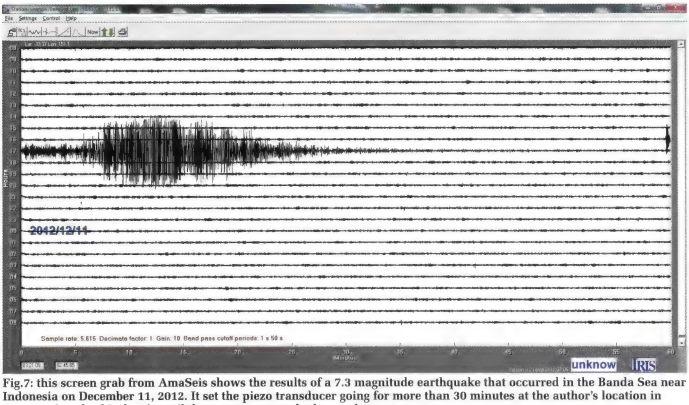


Fig.7: this screen grab from AmaSeis shows the results of a 7.3 magnitude earthquake that occurred in the Banda Sea near Indonesia on December 11, 2012. It set the piezo transducer going for more than 30 minutes at the author's location in Berowra (north of Sydney), until the wave sequence had passed.

serial cable to make the connection. One option is to use the abovementioned AXE027 PICAXE USB Download Cable. **However, before connecting this cable, you first have to install the driver that you downloaded earlier. This is necessary for the computer to automatically recognise the cable when it is subsequently plugged in.**

The AXE027 PICAXE USB Download Cable is included in the PICAXE-08M Starter Kit from Altronics – Cat. Z6101. Alternatively, you should be able to use other USB-to-serial cables, such as the Jaycar XC-4834. Unlike the Revolution Education cable which comes fitted with a 3.5mm stereo jack socket at one end, this latter cable is fitted with a DB9M connector.

In each case, it's just a matter of following the instructions supplied with the cable to install it.

Programming editor

With the cable connected, the next step is to launch the *PICAXE Programming Editor*, then click the Options button, select the Mode tab and select the device to be programmed – either a PICAXE-08M or a PICAXE-08M2 (see Fig.3). That done, click the Serial Port tab, scroll down and select the relevant COM port (see Fig.4), then click OK.

You are now ready to program the PICAXE. To do this, click the Open button on the main window and load the program listing (Fig.5). To save you typing it out, this listing is available for free download from the SILICON CHIP website. The file you need is called *SeismographV2.bas*.

Alternatively, you can type the listing out (it's shown in the panel at right) and then copy and paste it into the *PICAXE Programming Editor* window (or you can just type it in directly).

It's now just a matter of clicking the Program button to download the software into the PICAXE.

When you have loaded the software, you can see the transmitted data by looking at the *PICAXE –> Terminal* drop down menu – see Fig.6. Check that the baud rate is 4800. The value transmitted is between about 400 and 600 when the seismograph is at rest and should cover from 0 to nearly 1000 with a gentle, sustained blow on the seismograph bar.

If this is incorrect, you will have to adjust the position of the metal vane and/or the sensitivity control (VR1) until you do get the full range.

In the *Option* window, you can see which serial COM port the data is being sent through. Adjust the alarm thresholds in the program to be 100 above or below the resting value. If you make the thresholds too close, the seismograph might cry "wolf" with every breeze or footstep.

Be aware also that small power supply "glitches" caused by stoves, heaters or air-conditioners might make the alarm give a single "chirp". A real quake, however, produces a very distinct "hee-haw" sound with every "swing" of the bar.

Setting up AmaSeis

You must now close the *PICAXE*

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Seismograph Program Listing

```
main:
  readadc10 4,w1      ' makes a 10 bit A-D conversion of the value at input 4 and sends to w1
  sertxd (#w1,cr,lf)  ' sends the value at w1 out to the Amaseis program
  if w1>600 then top  ' sets the alarm threshold above the resting signal value (about 500)
  if w1<400 then bot  ' sets the alarm threshold below the resting signal value
  pause 162           ' tells the picaxe to pause for 162 ms  and gives 6 data feeds per second
  goto main           ' loops the program back to the start

top:                  ' when the signal >600
  sound 2, (100,10)   ' output 2 sounds a high note
  goto main           ' loops the program back to the start

bot:                  ' when the signal <400
  sound 2, (50,10)    ' output 2 sounds a low note
  goto main           ' loops the program back to the start
```

Programming Editor to free the COM port, so that you can install AmaSeis. Once it's installed, use Explorer to display the files associated with AmaSeis, then use Notepad to open the "AS1 Configuration Settings" file and change BAUD=2400 to BAUD=4800 to match the PICAXE baud rate.

That done, open AmaSeis using its desktop icon, go to Settings and alter the following parameters:
(1) Set the COM port number so that it is the same as for the PICAXE; and (2) Set Device to AS-1 (this was a commercial circuit using an older PIC chip).

Other settings such as Station Name, Set Zero, Gain and Filters can be set later on, when the seismograph is running.

Now close AmaSeis and then re-open it again from the desktop icon. You should now see a displayed seismograph line but it may be hidden above or below the screen if AmaSeis has not correctly reset it zero. In *Settings –> Show Data Values*, you should see the data value read by AmaSeis. You might then need to use "Set Zero Level" to correct for the data value error from zero.

On the main display screen, you should now see the seismograph line progress across the screen each hour. In *Settings –> This Station*, you can add your location and coordinates, while in *Settings –> Helicorder*, you can adjust the gain (5 or 10 or 20) of the computer. You should also turn Glitch Removal and Filters on.

The program even appears to correct (at the end of each hour) for the few seconds gained or lost by inaccuracies in the PICAXE timing. The time displayed by the program is Universal Time.

Other Uses For AmaSeis

Although AmaSeis is designed for use with seismographs, it could easily be put to other uses.

For example, it can be used to provide a permanent record of any activity monitored by the PICAXE's A/D inputs, eg, freezer, greenhouse or home-brew temperatures; solar panel output; cat flap position, etc. And with the PICAXE programmed with the alarm option and the added piezo transducer, it can have even more uses.

Analysing the display

When you detect a quake, the program also has a number of options for analysing the display. "AltPrint Screen" lets you copy a quake plot to Paint for scaling or printing. And of course, if the serial cable is disconnected, the seismograph and its PICAXE-based detector circuit will operate as an independent earthquake and tsunami warning device.

For further seismograph design ideas, including magnetic detector and amplifier circuits, point your browser to **http://sydney.edu.au/science/uniserve_science/school/Seismograph/index.html**

Finally, my thanks to Manfred for his help with the circuit design and for his continued enthusiasm for the project. SC

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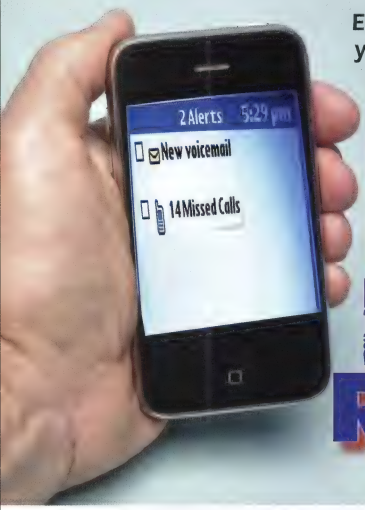


Ever missed an important call because you and your mobile were separated? Here's the SILICON CHIP solution!

Mobile Phone LOUD RINGER!

by John Clarke

You know the scene: you're working outside and the mobile is inside. Or maybe you've left it in the work ute while you're at a job. Either way, you pick up the phone and all you see is "missed calls". Rats!

Sure, they could have left a message (but many people don't like doing that). Either way, you now have to return the call (at your cost!) and the odds are it's someone trying to flog you something you don't want, someone who wanted you to do a job but has gone elsewhere in the meantime, someone seeking a donation to a worthy cause, or even a wrong number.

Whatever it is, it's an inconvenience. And an expense.

Wouldn't it be nice if you could hear the phone ring 'cos it's now **REALLY LOUD**? Yes it would be!

We can't change the ring volume on your phone itself but we can help you out by adding a mobile phone ring "extender".

This simple device picks up the vibration of the mobile phone ringing (and pretty well all mobile phones have this feature so you can "feel" the phone ringing in a noisy environment) and uses that vibration to trigger a loud piezo siren that you can position wherever you like.

The vibrating alert on a mobile phone typically produces a 150-180Hz "buzz". It's produced by a small electric motor running at around 10,000rpm that rotates an eccentric (or off balance) mass on its shaft.

The Mobile Phone Ring Extender (let's call it the MPRE for short) is housed in a small case. The idea is that when you don't want the phone in your pocket or even close by, you place it on top of the MPRE case.

The MPRE then provides a (very!) loud phone ring alert that allows you to get to the phone and hopefully answer it before it stops ringing.

How it works

Fig.1 shows the general arrangement. A piezo transducer is the sensor that detects the vibration from the phone. The vibration from the phone is transferred to the case lid and that movement is further transferred to the piezo element via an actuator made from a short length of Nylon or polycarbonate M4 thread, cut from a screw.

Signal from the piezo transducer is amplified and converted to a DC voltage. This DC voltage is monitored using a comparator that compares the voltage against a reference

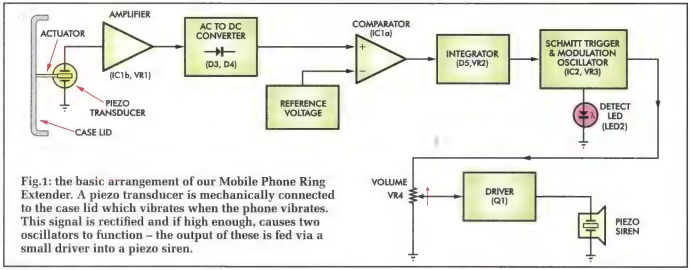


Fig.1: the basic arrangement of our Mobile Phone Ring Extender. A piezo transducer is mechanically connected to the case lid which vibrates when the phone vibrates. This signal is rectified and if high enough, causes two oscillators to function – the output of these is fed via a small driver into a piezo siren.

voltage. With no signal, the DC voltage is below the reference and the comparator output is low (near to the ground supply). With vibration detected, the DC voltage rises above the reference voltage and the comparator output goes high (towards the positive supply).

The following circuitry forms a delay circuit whereby the high level is integrated over time. This integrator is included so that brief vibrations – such as the phone bouncing to footsteps – are not sufficiently long enough to be detected by the following Schmitt trigger (IC2c).

Only longer periods of vibration that really do mean there's an incoming call are detected. The integrator delay is adjustable with VR2 so that the time period can be set correctly; that is, not too short to detect the placing of the phone onto the MPRE case but not too long so as to significantly delay the detection to an incoming call.

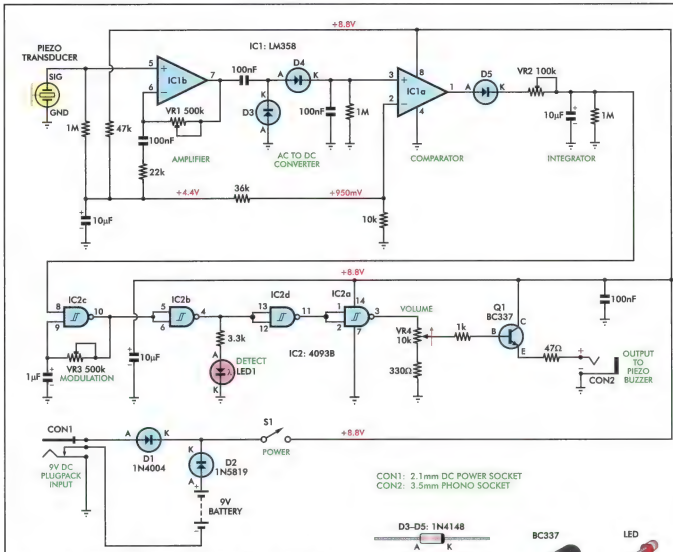
The Schmitt trigger is a part of the modulation oscillator and starts oscillation with sufficient signal from the integrator. The detect LED driven from IC2b visually indicates the detection of an incoming call. IC2b in turn drives IC2d and IC2a respectively and allows the modulation oscillator to switch the tone on and off. Modulation rate is adjustable using VR3.

Output drive from IC2a is adjustable with VR4 and the wiper voltage is buffered with voltage follower Q1 to drive the external piezo siren.

Circuit

Circuitry for the MPRE is mainly based on just two ICs, a dual op amp (IC1) and a quad Schmitt trigger NAND gate

Here's how it works: simply place your mobile phone on top of the Mobile Phone Ring Extender (with vibrate turned on). The unit detects the vibration from incoming calls and sounds the piezo siren at right. The siren shown is one of several options; more information is in the text.



MOBILE PHONE RING EXTENDER

Fig.2: the circuit is based on two low-cost ICs, a dual op amp (IC1) and a quad Schmitt trigger NAND (IC2). It can be operated from either a 9V battery or, for longer term operation, a 9V DC plugpack.

(IC2). Fig.2 shows the full circuit.

IC1b is the piezo transducer amplifier. This is biased at 4.4V using a voltage divider comprising a 47kΩ, 36kΩ and 10kΩ resistor string connected across the 8.8V supply. Pin 5 is held at this 4.4V via the 1MΩ resistor that provides a high impedance loading for the piezo transducer.

Amplifier gain is set by the 22kΩ resistor connecting to the 4.4V reference and VR1's setting. Low frequency roll off is at 72Hz, due to the 100nF capacitor in series with the 22kΩ resistor.

The amplifier mainly amplifies signal above 72Hz and does not amplify a DC signal. Gain is variable from 1-23.7, with VR1 set between zero ohms to 500kΩ respectively.

Output from IC1b is rectified using diodes D3 and D4. The 100nF coupling capacitor at IC1b's output only allows AC signal to pass and the signal is clamped at about 0.7V below 0V by diode D3. Positive signal passes through diode D4 and is filtered with a 100nF capacitor. The 1MΩ resistor discharges the capacitor over a 100ms period.

IC1a is the comparator that monitors the filtered DC voltage at the non-inverting input (pin 3) and compares this against the 950mV reference voltage at the inverting input (pin 2). The 950mV is derived from the same voltage divider that produced the 4.4V, only from the lower tapping across the 10kΩ resistor. With the pin 3 input lower than 950mV, IC1a's output is low, at near to 0V. When pin 3 voltage rises above 950mV, then IC1a's output goes high, at close to the 8.8V supply.

This high output from IC1a charges the 10µF capacitor via diode D5 and the resistance set by VR2. When IC1a's output is low, the 10µF capacitor discharges via the 1MΩ resistor.

When the 10µF capacitor is discharged, the pin 8 input to IC2c is low and the output at pin 10 remains high, because the NAND gate output will only go low when both the pin 8 and pin 9 inputs are high. The 1µF capacitor at the second input at pin 9 is charged to a high level via VR3. IC2b inverts this high to a low output at pin 4 and so IC2d's output also remains with its output (pin 11) high. IC2a inverts this high so that its pin 3 output sits low and there is no drive to the piezo siren.

Here's what it looks like fully assembled, with the end-on view above showing the minimal controls. We used a "remote control" case because it already has provision for an internal 9V battery (battery and output sockets are on the side of the case in purpose-cut holes).

Upon detection of a vibration signal (and the IC1a output going high), the resulting high at pin 8 of IC2c's input allows the modulation oscillator to run. IC2c's output goes low and discharges the 1µF capacitor via VR3 whereupon IC2c's output goes high again to recharge the 1µF capacitor via VR3. This cycle repeats.

The input threshold for the NAND gate includes hysteresis that is internally provided within IC2.

Each time IC2c's output is low, IC2b's output is high and this also drives the detect LED via a 3.3kΩ resistor. The LED switches on and off at the modulation rate. IC2d buffers the modulation signal from IC2b while IC2a inverts the logic level again and applies the signal across the volume potentiometer (VR4). The output at the wiper drives the base of the emitter follower Q1. When the base voltage goes high, the emitter of Q1 supplies power to the piezo siren via CON2. A 330Ω resistor is included in series with the volume control (VR4) to reduce the "dead area" at the full anticlockwise pot travel where there is no volume. The wiper voltage for VR4 needs to go above about 0.6V for Q1 to switch on.

The 330Ω resistor sets the wiper voltage at 268mV when IC2d's output is high and the wiper is set fully anticlockwise. Without this resistor, the wiper voltage would be 0V and would require more clockwise travel before sound is heard from the siren.

Power for the MPRE can be either from a 9V battery or a DC supply such as from a 9V plugpack. The 9V battery supply is via Schottky diode D2 providing reverse polarity connection protection for the circuitry with minimal voltage drop. Whenever power is connected via the DC socket, the battery is automatically disconnected. Both supplies are isolated from each other by the diodes.

With the 0.2V drop across diode D2, the rail voltage with a fresh battery is very close to 8.8V, as shown on the circuit diagram. It is usually a little higher from a plugpack because even though branded "9V", the output from these can be (and usually is) anywhere up to about 12V at low currents.

Why detect the VIBRATION ?

Why have we gone to the trouble of detecting the vibration of the mobile phone? Why not simply detect the ring of the phone, say via a microphone, and use that to trigger the siren?

The reason is pretty simple: there are so many ring tones, so many tunes and so many variations on a theme in mobile phones that it was difficult to create a "one size fits all" detector; one that would work with everything.

And there was a second problem: how sensitive do you make it, so that it reliably triggers with a ring but doesn't false trigger when the dog barks?

Just about everyone has their vibration alert turned on all the time – even if the ringer itself is turned off (and that was another problem!). So the vibration detector was the way to go – reliable, worked with all phones, etc.

Believe it or not, we tried yet another method of detection based on RF. You know how the phone's handshaking (beep beep, beepity beep beep) gets into everything?

We thought this would be a great way to detect an incoming call even though mobile phone transmitter power varies significantly with distance to the cell tower.

But again, we couldn't make it reliable with all brands of phone – and it even had more problems detecting 3G calls than it did 2G. 4G? Don't know – none of us has a 4G phone!

So we figured detecting the vibration was the best option!

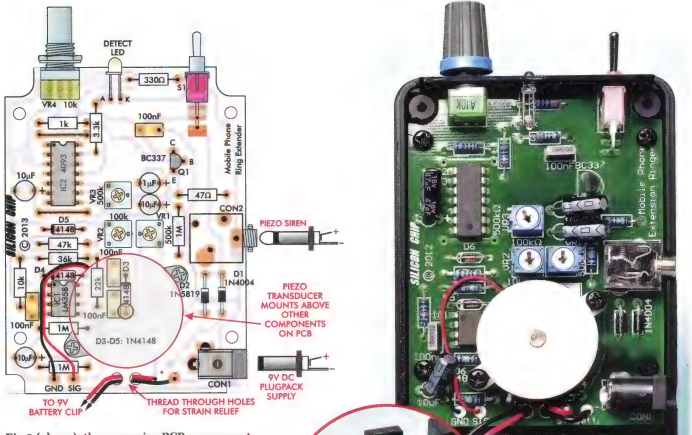


Fig.3 (above): the same-size PCB component overlay, with an early prototype photo alongside (some components have been changed since the photo was taken). While the electrolytic capacitors are shown above in traditional position, the photo at right shows that these are all "laid over" to give room for the case lid to fit. Also, the two links shown above will only be required if the PCB is single-sided.
Inset at right is a close-up of the piezo transducer with a short length of 4mm nylon screw thread, used to provide a mechanical connection between the transducer and case lid. It simply relies on touching the lid; it is not glued in.

"At rest" current consumption is about 6mA.

Construction

All components for the MPRE are mounted on a PCB coded 12110121 and measuring 63.5 x 86mm. The PCB and components are housed in a "remote control" case measuring 135 x 70 x 24mm. This case is used because it also houses the 9V battery. A panel label attaches to the front face of the case (or, depending on the kit source, may be supplied already printed).

The PCB is designed to mount onto the integral mounting bushes within the box. Make sure the corner edges of the PCB are shaped to the correct outline so they fit into the box. They can be filed to shape if necessary using the PCB outline shape as a guide.

It is rare to find faults with modern PCBs, but it's worth checking the PCB for breaks or shorts between tracks or pads. Repair if necessary.

Check the hole sizes for the PCB mounting holes – they should be 3mm in diameter.

Assembly can now begin. Start by the inserting the resistors and use the resistor colour code table to help in reading the resistor values. A digital multimeter can also be used to measure each value – in fact, it's a good idea because many colour bands on resistors look very similar.

If you use a PCB purchased from the SILICON CHIP Partshop, it will be double-sided but other PCBs may be single sided and require two wire links (above and below IC2) to be soldered in.

The diodes can now be installed and being polarised, must be mounted with the orientation as shown. IC1 should be mounted directly on the PCB since there is insufficient room (height wise) for a socket once the piezo transducer is installed. IC2 can be mounted on a socket if desired.

When installing the ICs, take care to orient them correctly with the notch (or circle marking pin 1) as shown on the overlay.

Capacitors can be mounted next. The electrolytic types must be oriented with the shown polarity and far enough above the board (~6mm or so) so that they can be bent over to lie parallel, or near-parallel, to the surface. Otherwise you will not be able to put the lid on. This simply means you need to have sufficient capacitor lead length to allow each part to bend over.

Trimpots VR1-VR3 can be mounted next. They're not all the same – VR2 is 100kΩ (code 104) while the others are 500kΩ (code 504). Transistor Q1 is next to install.

CON1 (DC input socket) and CON2 (3.5mm output to siren) should be mounted right down on the PCB surface.

Potentiometer (VR4) and the PCB mounted switch (S1) can also be fitted.

LED1 and its series 3.3kΩ resistor can be regarded as optional if you don't require a visual indication of detected ring (leaving them out will also save a little bit of power if running from a battery).

If you do fit them, mount LED1 horizontally but at a height of 6mm above the PCB. Bend its leads at 90°, 7mm back from the LED body making sure the anode lead is to the left.

Panel holes

The side of the base of the case needs to be filed using a rat tailed file to allow connections to both CON 1 and CON2 through the side the case. Position the PCB in the base of the case with the PCB mounting holes aligned with the mounting pillars. Mark out the socket positions and file to shape.

A similar shape is required on the lid and its position is found by placing the lid onto the base of the case (with the PCB removed) and filing out the lid half for a circular hole.

Before securing the PCB in place, drill out the small front edge panel for the potentiometer, switch and LED (if used). A drill guide is available and is provided with the front panel label. This can be used as a guide as to the drill hole positions.

Nuts for the potentiometer and 3.5mm socket are not required. The potentiometer shaft is fitted with a knob after the front edge panel is placed over the shaft, switch S1 and the LED.

Wiring

Follow the wiring diagram to make the connections from the piezo transducer to the PCB. The battery clip lead is inserted first from within the the battery compartment before being looped through the strain relief holes and attaching to the PCB. Make sure the polarity is correct with the red battery clip lead as the plus lead.

Piezo transducer

The piezo transducer is raised above the PCB using two 6.3mm tapped standoffs. M3 screws secure the standoffs from the bottom and the piezo is secured with two more M3 screws into the standoffs. Note that the mounting holes in the piezo transducer mounting lugs will need to be carefully enlarged with a 3mm (or 1/8") drill bit.

The wires are attached to the 'Sig' and 'GND' inputs on the PCB.

An M4 Nylon screw, which provides the mechanical connection between the vibrating case lid and the piezo transducer, is cut so that you have a 4mm long length of thread. The head of the screw is not used. This length is inserted into the centre hole of the piezo transducer.

The length of this screw thread is important. Too short and it will not make contact with the lid. Too long and the lid will not fit onto the case without excessive bowing.

The PCB is secured to the base of the case using four M3 x 6mm screws that screw into the integral mounting bushes in the box.

Label

As mentioned earlier, some kitset suppliers are now pre-printing labels onto their cases, so you won't have to do anything.

But if yours is blank, or you've assembled your own bits, the panel label for this project can be downloaded from the SILICON CHIP website (www.siliconchip.com.au). When downloaded, you can print onto paper,

Resistor Colour Codes

	No.	Value	4-Band Code (5%)	5-Band Code (1%)
☐	3	1MΩ	brown black green gold	brown black black yellow brown
☐	1	47kΩ	yellow violet orange gold	yellow violet black red brown
☐	1	36kΩ	orange blue orange gold	orange blue black red brown
☐	1	22kΩ	red red orange gold	red red black red brown
☐	1	10kΩ	brown black orange gold	brown black black red brown
☐	1	3.3kΩ	orange orange red gold	orange orange black brown brown
☐	1	1kΩ	brown black red gold	brown black black brown brown
☐	1	330Ω	orange orange brown gold	orange orange black black brown
☐	1	47Ω	yellow violet black gold	yellow violet black gold brown

Parts List – Mobile Phone Ring Extender

1 PCB coded 12110121, 63.5 x 86mm
1 panel label 113 x 50mm
1 remote control case 135 x 70 x 24mm (Jaycar HB5610)
1 piezo siren (Jaycar AB-3456, Altronics S-6127)
1 piezo transducer (Jaycar AB3440, Altronics S6140)
1 PCB mount SPDT switch (Altronics S1421 or equivalent) (S1)
1 PCB mount DC socket (Jaycar PS-0520, Altronics P0621A) (CON1)
1 3.5mm stereo PCB mount socket (Jaycar PS-0133, Altronics P0092) (CON2)
1 3.5mm mono plug [to connect siren] (Jaycar PP-0144, Altronics P-0028)
1 knob to suit VR4
1 9V battery, with clip
8 M3 x 5mm screws
2 6.3mm long M3 tapped nylon spacers
1 M4 polycarbonate or Nylon screw (cut for a 4mm thread section without the head)
4 PC stakes (optional at wiring points)
Suitable length polarised figure-8 cable if siren is to be remotely mounted

Semiconductors
1 LM358 dual op amp (IC1)
1 4093 CMOS quad Schmitt NAND gate (IC2)
1 1N4004 1A diode (D1)
1 1N5819 Schottky diode (D2)
3 1N4148 switching diodes (D3-D5)
1 BC337 NPN transistor (Q1)
1 3mm high intensity LED (LED1)*

Capacitors
3 10μF 16V PC electrolytic
1 1μF 16V PC electrolytic
4 100nF MKT polyester (code: 104)

Resistors (0.25W, 1%)

3 1MΩ	1 47kΩ	1 36kΩ
1 22kΩ	1 10kΩ	1 3.3kΩ*
1 1kΩ	1 330Ω	1 47Ω

1 100kΩ horizontal mount trimpot (code 104) (VR2)
2 500kΩ horizontal mount trimpots (code 504) (VR1,VR3)
1 10k log 9mm potentiometer (Jaycar RP-8610 or equivalent) (VR5)
** optional (see text)*

Figs. 4 & 5: front panel artwork for the Mobile Phone Ring Extender, and below right the template for drilling the end (top) panel holes. These images can also be downloaded from www.siliconchip.com.au

sticky-backed photo paper or onto plastic film.

When using clear plastic film (overhead projector film) you can print the label as a mirror image so that the ink is behind the film when placed onto the panel. Once the ink is dry, cut the label to size.

Glue the panel to the lid of the case with silicone sealant, contact adhesive or similar glue. Where you use the clear film, a contrasting silicone colour can be used such as white or grey to show up the printing on a black panel.

Clear silicone can be used for non-white panels since the panel itself will provide the contrast against the printed label.

Piezo siren

The piezo siren is pretty loud – you might find it loud enough to mount close to the MPRE via the short length of cable it comes with.

Or you might prefer to mount the siren elsewhere, where it can be more easily heard – outside, for example. In this case, you'll need to connect a suitable length of figure-8 polarised cable to the siren and in either case, you'll need to solder on a 3.5mm mono plug so that it can plug into the MPRE. The siren is polarised – the red (+) wire goes to the centre pin on the 3.5mm plug.

If you do decide to mount the siren outside, you will need to fit it so it's protected from the elements – under an eave, for example.

Within reason, there is no limit (say to a standard suburban house boundary) to the length of wire between the piezo siren and MPRE.

Testing

Initially, don't connect the siren – it will deafen you at close range!

When you switch on, using a 9V battery, there should be around 8.8V between pins 4 & 8 of IC1 and between pins 7 and 14 of IC2. Pin 2 of IC1 should be about 950mV above 0V (the GND terminal). Pin 5 of IC1 should be about 4.4V above 0V.

Note that these voltages might differ a little from these values depending on the supply voltage.

With a plugpack supply they will almost certainly be higher but still should be in much the same ratio.

Now set VR1, VR2 and VR3 to mid position and attach the piezo siren.

You should be able to trigger the MPRE into operation by repetitively tapping the case. That should introduce sufficient vibration to be detected by the piezo transducer and you should hear the alert sound and see the detect LED flash.

You can adjust VR3 and VR4 for the desired sound, with VR3 adjusting the rate of switching the tone on and off. Clockwise will increase the frequency.

Final testing is done with a mobile telephone (set to vibrate). Place the phone on top of the MPRE and make a call to the phone using another phone.

Again, the MPRE should begin flashing the detect LED and the siren should sound. If neither happens, adjust VR1 further clockwise for more sensitivity.

VR2 should be adjusted so that the MPRE does not sound unless there is an incoming call.

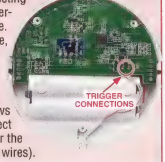
It should not detect a single tapping on the case with your finger nail. VR2's adjustment is usually at mid-setting but may need to be set more anticlockwise to ensure that an incoming call is detected without too much delay or more clockwise to prevent detection of single tapping on the case. SC

Another "siren"?

Two piezo sirens have been specified for this project but since building the prototype, we've come across a possible alternative – albeit not made for the purpose but nevertheless we believe would be quite suitable.

By coincidence, Jaycar Electronics advertised a "Water Leakage Alarm" (Cat LA-5163) in the January issue of SILICON CHIP for just $9.95 – cheaper than either of the piezo sirens. We weren't particularly interested in detecting water but we were interested in the alarm side.

On opening the case, we found it very easy to connect to the two solder pads which trigger the alarm. The photo above shows the two pads to connect to (clip off or unsolder the existing water sensor wires).



Jaycar Electronics

Better, More Technical

BACK TO WORK

FEBRUARY EDITION

Prices valid until 28/02/2013

DUAL CHANNEL OSCILLOSCOPES

- USB interface • Colour screens
- Includes 2 x 10:1 probes, EasyScope software & USB cable
- See online for more details

25MHz

Ideal for the advanced hobby user or technician and suited to audio work.

- 145mm colour TFT LCD
- Size: 310(W) x 150(H) x 130(D)mm

QC-1932 ***was $599.00***

$499.00 SAVE $100

100MHz with 7" Colour Screen

Enhanced performance, professional level test instrument for the technician, design engineer or development laboratory. Includes a carry bag.

- 178mm colour TFT LCD
- Size: 340(W) x 150(H) x 110(D)mm

QC-1934 ***was $1149.00***

$899.00 SAVE $250

Digital Frequency Counter

2.7GHz dual range frequency counter for measuring functions of frequency period totals and self checking. The counter readout has a large 10mm high intensity 7 segment LED display with gate time and data hold function.

- Frequency range: 10Hz - 2700MHz
- Size: 230(W) x 210(H) x 76(D)mm

QT-2202 ***was $169.00***

$149.00 SAVE $20

Cat IV DMM with USB Interface

This meter can also be used as a data logger which can be connected to a PC via wireless USB interface. Double moulded case and IP67 rated.

- True RMS
- Data hold, auto ranging
- 10A max AC or DC
- 1000V max AC or DC
- Size: 182(H) x 82(W) x 55(D)mm

QM-1575 ***was $199.00***

$179.00 SAVE $20

Soldering Iron Starter Kit

All the soldering essentials for the hobbyist. The sum of the individual parts is more than double the price we are selling this kit for. Excellent value!

- Includes: 240V 20/130W soldering iron, spare tip, stand, 1mm solder, and metal solder sucker

TS-1651 ***was $24.95***

$19.95 SAVE $5

Mini Bluetooth® Dongle

Connect a wide variety of popular Bluetooth® devices to your PC, including modern Bluetooth® Low Energy devices.

- Bluetooth® V4.0 Class 2 (also Bluetooth® 2.1 + EDR)
- Transfer rate: 3Mbps
- Plug 'n' Play Windows

XC-4956

NEW **$19.95**

12V 10A Intelligent 5 Stage Battery Charger

Charge and maintain your 12V batteries with this microprocessor controlled charger. Features reverse polarity protection, overheat protection, voltage compensation, fan cooling and more. 5 stage charging includes soft start, bulk charging, absorption, float and pulse.

- Suits WET/Flooded, GEL, AGM, MF, VRLA, Calcium type lead acid rechargeable batteries
- Size: 230(H) x 170(W) x 140(D)mm

MB-3625

NEW **$99.95**

DUE EARLY FEBRUARY

Electric Fence Energiser - 10km

Capable of electrifying up to 10km of fencing for enlosing livestock such as horses, chickens, cattle, sheep etc. Installation is simple, connect up to a 12VDC lead acid battery via the alligator clips, and then using the binding posts, wire up to a suitably fitted electric fence wire and ground stake.

- 12VDC battery operated (recommended 4Ah or larger)
- Size: 171(H) x 95(W) x 45(D)mm

ME-6800

$79.95

Jacob's Ladder MK3 Kit

Ref: Silicon Chip Magazine February 2013

A spectacular rising ladder of bright and noisy sparks for theatre special effects or to impress your friends. This improved circuit has even more zing and zap than it's previous design from April 2007 and requires the purchase of a VS Commodere 12V ignition coil (available from auto stores and parts recyclers). Kit supplied with silk-screened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC, PCB mount components and pre-cut wire/ladder. Powered from a 12V 7Ah SLA or 12V car battery.

KC-5520

DUE MID FEBRUARY

NEW **$49.95**

Battery not included

2.4GHz Wireless Stereo Speaker System

Operate as a pair for stereo sound or use as standalone speakers to listen to music in two separate rooms. To charge, simply place them on the induction pads on the base unit. Perfect for entertaining guests!

- 2 x 3W speakers
- 2.4GHz wireless speakers
- Dock for iPhone®/iPod®
- Satellite speakers with induction charge
- Base unit size: 335(L) x 148(W) x 28(H)mm
- Speaker size: 120(L) x 107(W) x 129(H)mm

AR-1887

iPhone® not included

NEW **$169.00**

HD Car Event Recorder with LCD & GPS

Mounts to the car windscreen to record vision, audio, GPS coordinates and speed to an SD memory card (available separately), which can be played back on the 2.4" colour screen or a PC to prove what happened in a car accident. Features HDMI output, infrared LEDs to improve night time recording.

- Built-in GPS & G-sensor
- 720P / H.264 / AVI or MP4 compression
- Storage consumption: 1GB = approx. 25mins
- 95° wide angle lens • Supports SDHC cards up to 32GB

QV-3793

NEW **$199.00**

TOOLS FOR THE TRADE

SLA Battery Boxes

Protect your batteries with these sturdy boxes. Perfect for mounting in your boat, trailer or caravan. Includes mounting clamps and lid strap to secure the box properly in place.

NEW from $24.95

Suits 40Ah SLA batteries
HB-8100 $24.95
Suits 100Ah SLA batteries
HB-8102 $29.95

SLA battery not included

DUE EARLY FEBRUARY

Eyeglass Repair Tool Kit

An easy way to repair eye glasses without the frustration of handling tiny screws. Includes unique snap-off screws.

- Repairs most eye glasses instantly

TD-2087

NEW $3.95

Eyeglass not included

Universal Drill Press Stand

Convert your standard power drill or rotary tool into a drill press with this adjustable stand. Built-in press depth gauge for accurate drilling and adjustable limiting brace.

- Drilling depth: up to 60mm
- Size: 497(H) x 350(W) x 160(D)mm

TD-2463 $29.95

Drill not included

Large Glue Gun - 40W

Great for quick and easy low stress repairs to timber, cardboard, paper and many household materials. Perfect for occasional work around the house.

- 240VAC
- 11mm Glue sticks pk6 to suit **TH-1995** $4.95

TH-1992 *was $22.95* $17.95 SAVE $5

SERVICE AIDS

Polyurethane Potting Compound

Composed of a polyurethane base designed to electrically insulate and protect against dust and moisture.

- 70ml

NM-2016 $9.95

portasol Gas Soldering Tool Kit

Features 90 minute run time, 10 second fill, maximum 1300°C temperature and 40 second heat up. See website for contents.

TS-1328 *was $159.00* $129.00 SAVE $30

Butane gas refill available:
NA-1020
$5.95

6-Piece Screwdriver Set

Contains all the smaller sizes you need for working on electronic gear. They have ergonomic handles with excellent non-slip grips. See website for contents.

- Insulated
- Case size: 192(L) x 130(W) x 26(H)mm

TD-2026 $19.95

100-Piece Driver Bit Set

Excellent driver bit set that contains just about every bit you could ever use. It has a magnetic holder, adaptors, Phillips and slotted bits, torx, and even a wing nut driver. Fantastic! See web site for full contents.

- 100 piece

TD-2038 $19.95

18-Piece Mixed Bit Set

A collection of commonly used driver bits in a handy rubber edged case. All stainless steel. Driver not included. See website for contents.

- Stainless steel
- Case size: 115(L) x 50(W) x 31(D)mm

TD-2111 *was $29.95* $19.95 SAVE $10

Wire Glue

A conductive adhesive that enables you to make solder-free connections when you aren't able to solder. Lead-free, cures overnight.

- 9ml

NM-2831 $9.95

Gas Torch

Very versatile and ideal for brazing, silver soldering, jewellery work, plumbing or general hobby use.

- 1300°C adjustable flame
- Size: 155(H) x 35(Dia.)mm

TS-1660

Butane gas refill available:
NA-1020 $5.95

$39.95

Modular Crimp Tool

This tool will cut, strip and crimp flat telephone cable, or Cat 5e type cable.

- 4P/6P/8P/10P
- Interchangeable dies

TH-1936 $39.95

150mm Digital Caliper

Soluble oil, grease, dust and swarf are just some of the hazards measurement tools to deal with in a workshop. These calipers are IP54 rated to withstand all these nasties.

$39.95

- Resolution: 0.01mm
- Metric and imperial conversion
- Case and battery included

TD-2084

Limited stock. Not available online.

Temperature Controlled Soldering Station

An ideal entry-level soldering station for the hobby user. Comes with a lightweight iron with anti-slip grip and tip cleaning sponge, temperature adjustment from 150°C up to 450°C.

- 40W power
- Size: 135(L) x 82(W) x 70(H)mm

TS-1620 $59.95

Spare 0.5mm conical tip:
TS-1622 $8.95

Gaffa Tape

Preferred by the professionals. Leaves no residue behind and sticks to most clean surfaces.

- 40m roll

Black NM-2812
Silver NM-2814 $23.95 pp

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/02/2013.

TEST & MEASUREMENT

Mini Digital Multimeter

Great for the hobbyist, student, or person who needs a cheap and quick way to check a few basic electronic measurements. Test probes included.

- 2000 count display
- Size: 94(H) x 46(W) x 26(D)mm

QM-1502

$4.95

Dynamo-Powered DMM

Just crank the handle for 10 seconds to provide power for approx 10 minutes operation. Ideal for electrical emergencies on the car or boat.

$39.95

- Data hold
- 10A current
- Size: 152(L) x 78(W) x 45(D)mm

QM-1547 ***originally $79.95***

Digital Thermometer with K-Type Thermocouple

Suitable for the lab, workshop or in the field. Features an excellent measurement range from -50 to 750°C and a hold function to lock the reading on the display. Thermocouple included.

$29.95 SAVE $10

- Pocket size
- Accepts standard K-type thermocouples
- Size: 118(L) x 70(W) x 29(D)mm

QM-1602 ***was $39.95***

2-in-1 Network Cable Tester and Digital Multimeter

Ideal for network installers or technicians and will allow the user to easily check cable integrity or measure AC & DC voltage without needing to carry two separate devices.

$59.95 SAVE $20

- Autoranging
- 2000 count
- Cat III 600V
- Case included
- Size: 162(H) x 74(W) x 44(D)mm

XC-5078 ***was $79.95***

Professional Laser Distance Meter

This comprehensive measurement tool adds, subtracts and calculates area, volume and takes indirect measurements.

It stores up to 20 historical records. Battery and case included.

$149.00 SAVE $20

- Range: 0.05 to 50m ±1.5mm
- Min/max distance tracking
- Laser accuracy
- Size: 110(L) x 47(W) x 28(H)mm

QM-1621 ***was $169.00***

400A AC/DC Clampmeter

Easy one-hand operation makes this meter perfect for the working installer or tradesman. A quality, intermediate-level clampmeter with current ranges up to 400 amps AC and DC.

- Data hold, non-contact voltage, relative measurement
- Autoranging
- Diode test
- Jaw opening 30mm
- Size: 198(H) x 66(W) x 36(D)mm

$99.00 SAVE $20

QM-1563 ***was $119.00***

Electrical Tester with Polarity Checking & Light

The unit will indicate the nearest voltage up to 690V with polarity indication. It will also check for low impedance, continuity, do a single pole phase test and show rotary field indication. IP64 rated housing.

$39.95 SAVE $10

- Includes 2 x AAA batteries
- Size: 240(H) x 78(W) x 40(D)mm

QP-2286 ***was $49.95***

Digital Light Meter

A handy lightmeter for photography, lab work, architectural, engineering and construction. Measure incident light in 4 ranges (0.01 to 200, 200 to 2,000, 2,000 to 20,000 and 20,000 to 50,000 lux).

- 2000 count display
- Separate Photo Detector
- Size: 188(L) x 64(W) x 24(D)mm

QM-1587

$49.95

Moisture Level Meter

Featuring a simple to use and easy to read display, a bar graph extends up the screen indicating the amount of moisture. Can be used on timber, cardboard, paper, and even on hardened materials.

- Electrode length: 8mm
- Includes 2 x CR2032 batteries
- Size: 140(H) x 48(W) x 33(D)mm

QP-2292 ***was $69.95***

$49.95 SAVE $20

Non-Contact AC Voltage Detector

Detects AC voltages from 50 - 1000V. It can be used for detecting live mains in outlets, power boards or insulated wiring.

$19.95

- Green and Red LED indicators • Audible beeper indicator
- 2 x AAA batteries included • LED flashlight function
- 176mm long

QP-2268

Power Point and Leakage Tester

Test your power points using this versatile tester. It checks most types of power points within 110V to 240V for correct wiring and earth leakage circuit breaker trip levels.

QP-2000

$19.95

THOUSANDS SOLD!

Pro Sound Level Meter with Calibrator

Ideal for vehicle noise testing, race scrutineering, traffic noise, aircraft noise or any evidence-based noise testing. Conforms to IEC 61672-1 Class 2 for sound level meters.

- External calibrator
- Min/max measurement
- Backlit LCD
- Tripod included
- Size: 278(L) x 76(W) x 50(D)mm

$299.00 SAVE $100

QM-1592 ***was $399.00***

High Temperature Non-Contact Thermometer

Suitable for lab, furnace, forge and small-scale foundry work. The laser pointer allows for accurate placement of the measurement point and the 30:1 distance-to-target ratio allows for accurate measurement from greater distances.

- Temperature range: -50 - 1000°C (-58 - 1832°F)
- Built-in laser pointer
- Size: 230(L) x 100(H) x 56(W)mm

$169.00 SAVE $20

QM-7226 ***was $189.00***

HDMI Converters

Mobile High-Definition Link to HDMI Converter

Allows you to enjoy all the functions of your MHL (Mobile High-Definition Link) enabled Smartphone on the big screen. Use a HDTV remote to control a phone using the HDMI CEC function. A great way to turn a phone into a mobile and convenient media player.

- Size: 53(L) x 28(W) x 11(H)mm

WQ-7421 ***was $39.95***

$29.95 SAVE $10

HDMI to DisplayPort Converter

With many monitors now available with a DisplayPort input, this converter will allow you to plug the monitor directly into a HDMI output on a device. For example you could connect your Blu-Ray/DVD player, PS3, Xbox etc to any DisplayPort equipped monitor.

- Size: 82(L) x 44(W) x 23(H)mm

AC-1621 ***was $99.00***

$80.00 SAVE $10

HDMI to VGA Converter

Converts video from a HDMI source for displaying on older screens/projectors which only have a VGA input. Power is drawn from the HDMI port so no external power is required.

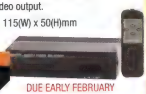
- Size: 250(L) x 37(W) x 13(H)mm

AC-1638

NEW $69.95

Remote Control Audio/Video Selector Switch

Connect up to 4 AV sources to one television and switch between them remotely. Features 4 x RCA composite/S-Video inputs and 1 x RCA composite/S-Video output.



- Size: 190(L) x 115(W) x 50(H)mm

AC-1654

NEW $44.95

DUE EARLY FEBRUARY

IR Remote Control Extender to suit Pay TV

Control a Pay TV, DVD or Blu-Ray player from another room up to 30m away. Simply install the rechargeable battery, RF transmitter and AA adaptor into the battery compartment of the remote control with the IR receiver in front of the device and away you go! Remote control not included.

- 3 selectable channels
- Mains adaptor included
- Size: 97(D) x 54(H)mm

AR-1821

$59.95

Universal Pay TV Remote

Replace your lost or broken pay TV remote control. Includes buttons to operate the special record, live pause and playback features of the latest recordable digital Pay TV services.

- Requires 2 x AA Batteries
- Approx 210mm long

AR-1737

$19.95

10" Portable PA System with 7-Channel Mixer

Includes 2 x 100W speakers, 7-channel mixer and microphone. Features built-in DSP effects, peak indicator and a variety of controls to fine-tune the audio frequency range. It can also play MP3s from an SD card or a USB flash drive.

- Supports balanced or unbalanced mic or music instruments
- Mains powered
- Size: 320(L) x 320(W) x 475(H)mm

CS-2549

NEW $499.00

DUE EARLY FEBRUARY

Stereo Audio Cat5 Baluns

Convert your stereo audio signal for connection to UTP network cable with these handy baluns. Capable of carrying signals up to 75m, the balun fly lead connects directly from your audio system to a RJ45 cable termination.

QC-3666

- Fly lead length: 140mm
- Size: 37(L) x 28(W) x 25(H)mm

NEW $19.95 EACH

Stereo RCA to Cat5 Audio Balun

QC-3666 $19.95

Stereo 3.5mm to Cat5 Audio Balun

QC-3668 $19.95

QC-3668

Fibre Optic Audio Lead

A range of fibre optic toslink cables with superb build quality. Suitable for achieving excellent audio reproduction in home cinemas that support Dolby Digital 5.1 (AC-3) surround sound, DTS, and more.

1m	WQ-7301	$14.95
3m	WQ-7302	$24.95
5m	WQ-7303	$39.95

NEW FROM $14.95

WQ-7301 shown

DUE EARLY FEBRUARY

2 x 2WRMS Portable Wireless Bluetooth® Speaker

Amplify and improve the quality of the audio playing from your device by pairing it to this Bluetooth® speaker. Runs on 4 x AAA batteries (not included) or via USB, has its own volume control and a wireless range of up to 8m.

iPhone® not included

- Output: 2 x 2W
- Wireless frequency: 2.4GHz - 2.480GHz
- Accessories: 1m AUX cable, 1m USB cable
- Size: 211(L) x 56(W) x 53(H)mm

XC-5205

NEW $39.95

Turn your old PC into a Media Centre

Just plug the VGA and USB cable into your PC and it will output a HDMI signal with audio/video.

- Powered from USB port
- Size: 80(L) x 55(W) x 11(H)mm

AC-1639

NEW $79.95

5.8GHz HDMI Sender/Receiver

Wirelessly pipe a 1080p HDMI source to a HDTV in another room. Saves you the hassle of installing wallplates, crawling into wall cavities, or running messy HDMI cable around the house. Comes with IR remote control.

AR-1874 AR-1877

- Range: up to 25m
- Includes IR extender function
- Receiver/sender size: 154(H) x 92(W) x 20(D)mm

AR-1877

$249.00

Spare receiver AR-1876 $149.00

4-input HDMI Switcher

AR-1874 $49.95

Ultra Slim LED/LCD Wall Brackets

Ultra thin tilting wall brackets for new LED/LCD TVs allow 15° of tilt and mount only 19mm from the wall once closed for optimal viewing experience. Mounting hardware and instructions included.

- Heavy duty steel construction
- Mounting profile: 19mm
- Load capacity up to 25kg
- VESA standard complaint

For 23" - 55" LED/LCD TV Sets

CW-2836 $39.95

For 40" - 65" LED/LCD TV Sets

CW-2838 $49.95

FROM $39.95

All savings based on Original RRP. Limited stock on sale items. Prices valid until 23/02/2013.

SECURITY

8 Zone Wireless Alarm Kit

Everything you need to get a basic wireless system set up in your home! Includes a key fob remote control, backlit LCD control panel, PIR sensor and two reed switches.

- Back-up battery
- Size: 210(L) x 113(W) x 127(H)mm

LA-5145 ***was $179.00***

$149.00 SAVE $30

Spare sensors and accessories to suit:

Pressure Mat	LA-5131	$29.95
Smoke Detector Sensor	LA-5132	$34.95
Indoor 120dB Siren	LA-5142	$39.95
Wireless PIR Sensor	LA-5146	$39.95

FROM **$29.95**

See online for our full range of spare accessories.

SPY CAMERAS

Hi-Tech covert surveillance options. Both look innocently simple, but secretly feature hidden technology.

Mini Digital Spy Camera

Thumb-sized clip-mount mini digital spy recorder delivers the ultimate in discrete portable photo and video recording.

- 1.3MP camera
- Requires a MicroSD card
- Rechargeable Li-ion battery lasts for 2 hours of non-stop recording
- Size: 57(H) x 22(W) x 19(D)mm

QC-8003 ***was $49.95***

Limited stock.

$29.95 SAVE $20

Ultimate "Spy" Watch Camera

Records video with audio in AVI format and downloads/charges via the supplied USB lead.

- 4GB internal memory
- Stores up to 120min of video
- Stores approx 1200 still pictures
- 640 x 480 video resolution
- Bezel size: 42(Dia.)mm

QC-8014

Camera

$69.95

Warning: These cameras should not be placed in areas where there is an expectation of privacy.

240VAC Plug-in Wireless Doorbell

Once plugged in, the battery powered wireless doorbell button can transmit up to 100 metres chiming out one of the 32 selectable melodies.

- Plug 'n' play
- Compact

LA-5029

NEW **$19.95**

Stand-alone HD Camera with Motion Detection

Compact, standalone day/night camera for home or office video surveillance. Features IR LEDs to see in complete darkness, and captures images at a resolution of 720p. Choose continuous or motion detection recording. Micro SD card up to 32GB required for over 9 hours of footage. Supplied with remote, AV, USB cables and rechargeable batteries.

- Continuous recording time: over 5 hrs
- Storage consumption: 1GB = approx. 18mins
- Charge time: approx. 3hrs
- Size with bracket: 67(L) x 67(W) x 65(D)mm

QC-8019

$99.00

Solar Powered Mini Window Alarms

2 for $30 save $9.90

Simply peel the clear backing from the self-adhesive, mount and position on the inside of a window - no tools required. Loud alarm sounds if triggered.

$19.95 ea

- Warning sticker included
- Size: 70(W) x 82(H) x 8(D)mm

LA-5003 shown

Mini Glass Breakage/Vibration	LA-5003 $19.95
Mini Magnetic Entry Alarm	LA-5005 $19.95

Solar Powered Annunciator Kit

With a wireless transmission range of up to 100m, this annunciator kit is a reliable solution for monitoring traffic in and out of driveways to shops, large commercial and rural properties. Easy to install and no messy wirings.

- Up to 100m transmission range
- Wireless IR detector
- Annunciator size: 143(L) x 110(W) x 50(D)mm
- Solar panel size: 173(L) x 123(W) x 14(D)mm

LA-5176

NEW **$99.00**

PROTECT YOUR CABLES

Expandable PPS Sleeving

This PPS (Polyphenylene Sulfide) monofilament sleeving is ideal in high temperature environments and offers a lightweight mechanical protection to your cabling.

- Expands up to 3 times its diameter
- Black, 2m length

3mm	WH-5584	$2.50
6mm	WH-5585	$2.95
10mm	WH-5587	$3.95
15mm	WH-5588	$7.95

NEW FROM **$2.50**

Heat Shrinkable Braided Sleeving

Used to provide added protection to cables against flames and abrasion.

- Shrink ratio: 2:1
- Shrink temp: 80°C
- Length: 1.2m

10mm	WH-5620	$3.95
20mm	WH-5622	$4.95
25mm	WH-5624	$5.95
30mm	WH-5626	$6.95

NEW FROM **$3.95**

Self-Closing Braided Wrap

Protect cabling neat and tidy, and protected from abrasion, wear and tear using this flame resistant self closing wrap.

- Flexible and lightweight
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6mm	WH-5630	$6.95
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NEW FROM **$6.95**

Screen your Visitors Day or Night

Cost effective slimline colour LCD video doorphone perfect for the home or office. Includes a 3.8" LCD screen, infrared CMOS camera, and an electronic door locking.

- Mains power supply included
- Monitor size: 125(L) x 215(H) x 23(D)mm
- Outdoor camera size: 100(L) x 134(H) x 38(D)mm

QC-3604 ***was $149.00***

$129.00 SAVE $20

DIGITAL Wireless Surveillance Camera Kits

Wireless camera and receiver packs provide simple and effective surveillance for the home or office. Using 2.4GHz DIGITAL technology to minimize interference and maximize range these camera and receiver packs give excellent performance. Available with a LCD screen receiver for viewing video on the go or with standard receiver for connection to an existing TV screen, both versions can also record video by adding an SD card (not included).

Receiver Features:

- Quad camera or single camera view
- Supports up to 4 cameras
- Accepts SD cards up to 32GB (sold separately)
- AV output for connection to separate monitor

Camera Features:

- Transmission range up to 100m line of sight
- 380TV Lines
- CMOS Image sensor
- Night vision distance up to 5m
- Weatherproof IP66 housing
- Size: 130(L) x 65(Dia.)mm

Camera with Standard Receiver

- Size:113(L) x 113(W) x 20(H)mm

QC-3672 $249.00

Camera with LCD Receiver

- 7" LCD screen
- Size: 197(L) x 121(H) x 21(D)mm

QC-3670 $349.00

Additional cameras available separately

QC-3674 $149.00

QC-3670

FROM **$249.00**

DO IT YOURSELF!

High-Energy Electronic Ignition Kit for Cars

Refer: Silicon Chip Magazine Nov and Dec 2012

Use this kit to replace a failed ignition module or to upgrade a mechanical ignition system when restoring a vehicle. Use with virtually any ignition system that uses a single coil with points, hall effect/lumenition, reluctor or optical sensors (Crane and Piranha) and ECU. Features include adjustable dwell time, output or follow input option, tachometer output, adjustable debounce period, dwell compensation for battery voltage and coil switch-off with no trigger signal.

$49.95

- Kit supplied with silk-screened PCB, diecast enclosure (111 x 60 x 30mm), pre-programmed PIC and PCB mount components for four trigger/pickup options.

KC-5513

Garbage & Recycling Reminder Kit

Refer: Silicon Chip Magazine January 2013

Easy to build kit that reminds you when to put which bin out by flashing the corresponding brightly coloured LED. Up to four bins can be individually set to weekly, fortnightly or alternate week or fortnight cycle. Kit supplied with silk-screened PCB, black enclosure (83 x 54 x 31mm), pre-programmed PIC, battery and PCB mount components.

NEW

$29.95

- PCB: 75 x 47mm

KC-5518

NOTE: Product will vary to one shown.

'The Champion' Audio Amplifier Kit with Pre-Amplifier

Refer: Silicon Chip Magazine January 2013

Suitable for general-purpose audio projects and supports microphone and electric guitar input. It uses the AN7511 audio IC to deliver 2W music power into 8 ohms from a 9 to 12V supply. Features low distortion, two inputs (mixed 1:1), mute and standby control. Power from 4 - 13.5VDC. See website for specifications. Kit supplied with silk-screened PCB, heatsink and PCB mount components.

NEW

$19.95

- PCB: 101 x 41mm

KC-5519

NOTE: Optional 10k ohm potentiometer for external volume control use **RP-7610** $1.95

Calling All Makers

If you spend late nights and weekends creating and making gadgets then we want to hear from you. To learn more about our exciting competition visit: **www.jaycar.com.au/makers**

LINE TRACER KITS

AI Dark Line Tracer Kit

Assemble this robot and watch it dutifully follow a thick dark line before it.

$19.95

SAVE $5

- Assembly time: 5 hours
- Requires 3 x AAA batteries
- Suitable for ages 8+
- Size:105(W) x 170(L) x 125(H)mm

KJ-8954 ***was $24.95***

Limited Stock. Not available online.

PC Programmable Line Tracer Kit

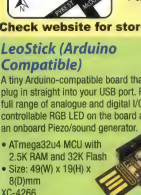
Learn about robotics and programming with this line tracer kit. Run it in line tracer mode by drawing a thick dark line on paper for the robot to follow.

$34.95

- Requires 2 x AA batteries
- Suitable for ages 12+
- Size: 120(L) x 64(W) x 55(H)mm

KJ-8906

WERRIBEE, VIC



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Check website for store trading hours

LeoStick (Arduino Compatible)

A tiny Arduino-compatible board that you can plug in straight into your USB port. Features a full range of analogue and digital I/O, a user-controllable RGB LED on the board and an onboard Piezo/sound generator.

$29.95

- ATmega32u4 MCU with 2.5K RAM and 32K Flash
- Size: 49(W) x 19(H) x 8(D)mm

XC-4266

LeoStick Shield to suit

XC-4268 $7.95

USBDroid, Arduino-Compatible with USB-host Support

This special Arduino-compatible board supports the Android™ Open Accessory Development Kit, which is Google's official platform for designing Android™ accessories. Plugs straight into your Android™ device and communicates with it via USB. Includes a built-in phone charger.

$69.95

- USB host controller chip
- Phone charging circuit built in
- 8 analog inputs
- MicroSD memory card slot

XC-4222

Terminal Shield to suit

XC-4224 $16.95

IR Temperature Sensor Module for Arduino

Connect this to your board and point it at a surface or heat source to remotely measure its temperature. This is our special version of the industrial infrared remote thermometer units with an onboard power supply, communication support and a software library and examples supplied.

$34.95

- 3.3 to 5V operation
- -33 to +220˚C measurement range, 1 second response time
- Size: 38(W) x 14(H) x 12(D)mm

XC-4260

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Rockingham	Ph (08) 9592 8000

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details.

Prices valid from 24th January 2013 to 23rd February 2013.

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Jaycar Electronics

Better, More Technical

PRODUCT SHOWCASE

Colour front panels for Altronics kits

Altronics Distributors have recently invested a significant amount of money in a new colour printer. "So what?" you ask!

This printer is a bit different: it will allow Altronics to print in colour on virtually anything, including front panels.

General Manager Brian Sorensen told SILICON CHIP that they will be supplying colour panels for the majority of their kits, including those in Jiffy boxes and other "off the shelf" cases.

"We're pretty excited about this," he said. "For too long constructors have been stuck with boring, single-colour silk screened panels, even when the SILICON CHIP original design was in colour."

"Now we can reproduce the same colours used in the original design, giving Altronics kits a degree of professionalism that no other kit supplier can match."

Altronics aims to supply colour panels on all new kit production runs and introduce them into their stores as stock runs low. Retail prices will be generally unaffected.

Contact:
Altronic Distributors Pty Ltd
PO Box 8350, Perth Busn Centre, WA 6849
Tel: 1300 780 999 **Fax:** 1300 790 999
Website: www.altronics.com.au

9.0MP Digital Pen Microscope

In addition to a 9.0MP Camera, the new OiTEZ eScope Filter Pro also has a built-in adjustable polarising light filter and is supplied with powerful measurement software.

With a 10X ~ 40X, and a 200X magnification the eScope Filter Pro is an innovative way to discover, capture and share microscopy. It can capture still images at a resolution of 640 x 480 through to 3488 x 2616 pixels and 15fps video with a resolution of 800x600 pixels.

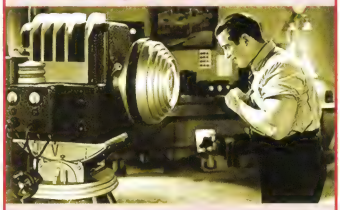
The powerful measurement software will measure many variations of lines, angles and circles making the eScope Filter Pro the ideal tool for use in quality control, setting up work instructions and reporting, in a multitude of industrial application. This versatile product will find a home in education and in various fields of science as well as being a useful tool for all sorts of hobbies.

It has a USB interface, built in 8-LED illumination with two stage control and is supplied with software on CD and a small adjustable stand. A range of optional stands is also available.

The MS1317 OiTEZ eScope Filter Pro is available from Wiltronics @ $148.00 inc. GST.

Contact:
Wiltronics Research Pty Ltd
U/4 Cnr Ring Rd & Sturt St, Ballarat Vic 3350
Tel: (03) 5334 2513 **Fax:** (03) 5334 1845
Website: www.wiltronics.com.au

It's Show & Tell Time – and it could earn you a $100 Gift Card!



Ok, you've put something really special together using Jaycar parts, so now it's time to Show & Tell.

Describe your design to Jaycar in 400 words or less, upload a few pics and you'll be in the running to win one of 50 $100 Jaycar Gift Cards! They'll also present your invention (or at least as many as space will allow) in the new 2013 Jaycar Catalog for all your friends, family and the extended Jaycar Family to see. If it's really scathingly brilliant, your design might also be featured as a project in SILICON CHIP!

Be it something simple, or something that completely automates your house, they want to know about it.

You'll find all the details and conditions of entry at www.jaycar.com.au/makers.asp.

But you'll have to be quick: ***entries close on February 5*** so get your skates on and send your project details in NOW!

SERVICEMAN'S LOG

Two tablets: both dropped, both fixed

Dave Thompson*

Laptops, smartphones & tablets can be quite easy to service, provided you can get the parts. Unfortunately, that's not always possible but persistence often as not pays off and you have a win.

IN THIS BUSINESS, advancing technology is – and always has been – a double-edged sword. The nature of servicing is constantly changing and not always for the better. Many bread and butter jobs that once kept small businesses ticking over have all but disappeared, either because new technology has rendered them obsolete (think belts and heads in VCRs) or because it's often simply cheaper to throw a faulty item away and buy a new one.

Another change I am seeing is in the spare parts area. Many previously repairable parts are now considered to be "consumables" or throwaway items, resulting in more lost service work. In the past, a phone call or an email was all it took to get virtually any part for any brand of laptop, monitor or printer, either directly from the manufacturer or from a distributor and usually at a reasonable cost.

These days, however, many manufacturers no longer make all the parts available. And that means we are often unable to repair equipment, even where the job would otherwise be reasonably straightforward. In fact, I am seeing this more and more with laptops. Many vendors now only offer a limited range of parts and even then only imported on demand from factories in Singapore, Taiwan or China.

Now while I accept that it's not practical for big computer companies to have a fully-stocked parts department in Christchurch, at least in the past they were happy to overnight the stuff from warehouses in Auckland or Wellington, or in rare cases, from Sydney or elsewhere in Australia. That meant that I'd only have to wait a few days for parts at most, a situation usually acceptable to vendors and clients alike.

Now, many parts are simply no longer offered. It's not hard to figure out why; having stacks of expensive spares sitting on warehouse shelves, sometimes for years, is not an efficient use of capital.

That's bad news, both for repair agents who rely on such work to keep their businesses ticking over and for clients whose sometimes not-very-old hardware cannot be economically repaired. And although some parts are still available, the increased cost and long lead times involved in importing them from Asia mean that it's often uneconomical to repair a device in any case.

What's more, for many clients, long turnaround times are simply unacceptable, especially if the machine is used for business. Telling a client that a job will take about four weeks and cost more than half as much as a new machine doesn't cut the mustard.

Adding to this, the current popularity of tablets and smartphones is now responsible for fast-diminishing sales of PCs and laptops. And while on the surface it would make sense to diversify into repairing such items, it isn't as straightforward as it seems. You may not need a lot of specialist kit to repair these devices but you do need to have a good general knowledge of the operating systems used and be good with the mechanical bits and pieces.

Unfortunately, parts availability is also a problem with these devices. I don't know what it's like in other countries but in my town, buying a screen for a name-brand tablet or smartphone isn't easy. What's more, when you do track them down, they're usually not cheap. It's no wonder clients often walk away when told the repair cost.

Nevertheless, muggins here does tackle such repairs. Just recently, for example, I had two rather challenging tablet repairs to contend with. In both cases, they were 10-inch models, one a big-name unit and the other a relatively unknown Chinese-branded machine. Both were very nice devices with capacitive touch screens and running Android 4.

Their problems started out in similar fashion. Both had been dropped and the reason their respective owners wanted them repaired was simple; they were only a few months old and the owners had no insurance to cover the cost of a new machine. My challenge was to find a screen for one and a motherboard for the other.

The brand-name unit had the smashed screen and an email to their NZ branch soon had me in contact with their spare parts department. Replacement screens were available but there would be a 4-week wait to get one to us here in New Zealand. I told them I'd have to get back to them once I'd talked to the client. After all, the repair would cost half the price of a new tablet once my own charges were factored in.

As for the Chinese tablet, I Googled the name and model number and quickly found the manufacturer's website. As is often the case though, this particular model wasn't listed on the site. However, there was a contact form so I filled it in and hit the submit button.

Items Covered This Month

- Two tablets: both dropped, both fixed
- LG 42PC1DV plasma TV
- Faulty mixer power supply
- Standard 8-Transistor SR-H505 Radio

*Dave Thompson, runs PC Anytime in Christchurch, NZ.

Saving An LG 42PC1DV Plasma TV From The Tip

It's not uncommon these days for late-model LCD and plasma TV sets with relatively minor faults to be thrown on the scrap heap. A. M. of Mount Isa, Qld recently rescued an LG 101cm plasma TV from the tip and restored it to full working order. Here's his story . . .

We live in Mount Isa, Queensland and I'm employed as a radio technician at one of the local mines. Thanks to a great roster, I have a few days off each week to look after the house, fix broken toys, do other repairs and spend time on several hobbies, including repairing defunct TV sets.

Fortunately, a modern plasma or LCD TV is fairly straightforward to repair in many respects, assuming that the screen is OK. One particular set that I tackled recently was an LG 42PC1DV, a rather nice 2006 101cm high-definition plasma which I acquired from the local tip.

It's really not unusual to find such sets there. One of the unfortunate realities of living so far out west is that no-one repairs TVs for a living. This means that by the time you freight one somewhere, a repair quickly becomes uneconomical, especially when many manufacturers price replacement boards in the $200 region.

Add in the cost of labour and it's no wonder that most people discard a faulty set and go for the new option.

Anyway, after getting the LG plasma home, I quickly set it up on the workbench in my den and switched it on. The result was better than expected. It fired up OK but the picture was missing every second line across the screen, so only half the picture information was displayed.

I removed the cover and it didn't take long to determine that all the supply rails were within specification. The culprit was most likely one of the sustain boards and a quick check soon revealed the Z sustain board had one of its two fuses blown. So the repair would be simple – I just had to get another board.

In the past, I have considered buying modules for these types of boards online. However, there's no guarantee that your board only has a fault in one particular module, so I usually go for a complete board.

This is where I have learned to go outside the normal channels in order to get spares. Freight charges are a real problem for those living in remote areas and when you add these to the prices most local companies charge for replacement boards, the costs soon mount up. This really annoys me because it often means that sets that can easily be repaired end up on the tip.

As a result, my usual trick for this type of repair is to source a board from overseas. In this case, the LG would only serve as a second set for the kids to connect their games console to, so I didn't want to spend too much money. You can find some boards on eBay or you can buy new or secondhand boards from the Chinese site Taobao.

The only drawback in the latter case is that you have to use a forwarding agency (try searching for "Taobao agent" on Google or YouTube and you will soon get the picture). Basically, Taobao is somewhat like eBay except you have to have your account in credit to buy and they mainly sell to Chinese customers.

This is why you use the agent. By using your favourite browser to convert the Taobao web page to English (Google Chrome is quite good), you can usually find at least a page of vendors willing to sell you a new or secondhand board. All you have to do is type in the board number.

I've learned a few tricks with this too. You can sort by new or used but the best indicator of who actually has stock (a lot don't) is to arrange the listing by the number of units sold in the last month.

Anyway, after a couple of emails to an agent, I was soon able to purchase a secondhand board and pay for the postage to Australia. Another tip here is to use the cheapest delivery method, usually China Post, although they do offer fairly good rates for a faster service.

In this case, my board arrived around three weeks later for not much more than $50 – a bargain. In the interim, I had replaced all the capacitors on the power supply board, although this set is one of the better ones with many (but not all) of the capacitors situated well away from the heatsinks. The power supply is also located in a well-ventilated spot.

There was only one thing left to do and that was to fit the new Z sustain board. That done, I nervously switched the set on and bingo, that was it. The set now came on with a perfect picture.

So the new board was certainly worth the wait but of course, that's not something you can always do in a professional repair environment – not when the customer wants the set back yesterday. However, when you are fixing something like this for yourself, the cost takes precedence over time and three weeks is really not too long to wait.

Before putting the cover back on, there is one modification I like to do with these type of sets. The heatsinks on the sustain boards in most sets get quite hot, so it's probably no wonder that they eventually fail in a hot climate. As a result, I have taken to fitting a 12V computer-style fan to them. At 12V, such fans are way too noisy but they are fine if run from a 5V rail.

It's also important to choose low-current fans, so that you don't overload the power supply. In this case, with the fans in place, the heatsinks were just warm to the touch.

Once the repairs had been completed, the old LG displayed an excellent picture. All I had to do now was track down a new remote control, as the original had gone missing

Obviously, a generic one would do but a genuine LG remote would be better, if only to avoid complaints from other members of the household. Another quick search online revealed an Aussie site that sells original units for a very reasonable price, so I've ordered one in.

All in all, it wasn't a bad win, especially considering I scored a 101cm plasma TV for less than $100. In fact, the set's so good I'm starting to think it would look better on our bedroom wall rather than sitting in the kids' room.

NEVERTHELESS, MUGGINS HERE DOES TACKLE SUCH REPAIRS...

After a few days and with no reply, I hit one of the bigger Chinese B2B (business-to-business) sites, a resource I am increasingly turning to in order to source hard-to-find or otherwise too-expensive hardware for smartphones and tablets. And I was in luck because it took just a few minutes to locate a suitable motherboard. In fact, there were several vendors offering the same board, all around the same price, and most also offered free shipping which is always a bonus.

I'd have to be careful though; some time ago, a client dropped in trying to source a replacement motherboard for his HP tablet computer which he had purchased in Singapore. Naturally, I steered him toward this site, thinking he'd likely find one there.

Well, he did but the "brand new" motherboard he ordered and received turned out to be a shabbily-refurbished one that didn't work when assembled into the chassis. He and the vendor ended up email-sparring but he didn't get very far – an all-too typical story sadly. Of course, I got a running commentary of this saga and was left with the feeling that somehow everything was my fault for suggesting the site in the first place.

On the other hand, I've purchased a lot of items from many different vendors via this website without problems. My philosophy is that as long as you exercise due diligence with potential sellers and trust your instincts, then you won't often go wrong. Besides, there is an internal payment system which withholds any funds from the vendor until you receive and are satisfied with the goods. So if things go wrong, you will eventually get your money back – as long as you pay via that system.

Anyway, I found a vendor who seemed OK and purchased the motherboard. It arrived within 10 days and went straight in. After soldering the battery and WiFi antenna leads, it powered on and ran like a dream. The cost of the motherboard was US$45.00, leaving a suitable margin for yours truly and giving the client an affordable repair.

In the event, he was over the moon, so in cases like this, it is well worth offering this type of repair. What's more, I've found that once you build a rapport with the suppliers and purchase a few items from them they will usually look after you from then on.

Getting back to the brand-name tablet with the smashed screen, I got hold of the client and broke the bad news. The cost of the screen was such that I didn't have the heart to add any mark-up on it. Instead, if he did go for it, I'd be happy to simply charge for the half-an-hour's labour it would take to do the job.

After some discussion, he gave me the go-ahead but I could tell he wasn't happy about it. It didn't seem to matter that I was offering the screen at cost plus GST. Instead, I had the feeling that he thought I was piling a huge margin on top of the screen price and trying to baffle him with "BS" when in fact I was doing him a favour.

Unfortunately, you just can't win in a case like this. Once I'd done the repair, I'd make only a small amount that likely wouldn't even be enough to cover the time I'd invested in the job. What's more, I'll probably then never see this client again because he thinks he's being "got at".

Anyway, the new screen arrived in 13 days and it took just 20 minutes to fit it and check the unit out. The screen literally pops out once two screws have been removed from the bottom of the tablet housing and it's then just a matter of unplugging a couple of ribbon cables and plugging them into the new screen which is then easily clipped back into place.

Having done this, I powered it up and made sure it was all working OK. This type of repair is easy but in this case, the cost and time involved in sourcing the parts caused problems. The client seemed to be satisfied with the results – after all, his near-new tablet was working perfectly again and carried a decent repair warranty. But again I got the impression he thought I'd diddled him. Such is the nature of the service industry!

Under the pump

Now for a complete change of subject. The advantage of having a dad

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column? If so, why not send those stories in to us?

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

who was a serviceman is that when he retires, you find yourself picking up some of his work. Well, my dad wasn't strictly a serviceman but as the neighbourhood "fix-it" guy, he ended up working on some weird and wonderful things.

I was at his house the other day and he asked me if I had time to look at something a neighbour had dropped off for him to fix. To be honest, I was surprised he'd taken the job on; his sight is failing and he simply can't put his skills (or his workshop) to good use any more. In fact, each time I visit him, I always seem to leave with a few more of his tools!

This time he had a small, electronic breast milk pump to look at (don't ask), which he said was working after he'd replaced a burned-out 12V plugpack power supply. However, when he returned it, the owner then reported intermittent problems with the power button.

The pump subsequently came back but Dad couldn't go much further with it, so I said I'd have a look. Two screws and several very tight plastic clips held it all together. Once these had been removed, I found that one end of the case held a kind of combined reservoir and pump unit while the other housed a small PCB. Aside from a bunch of surface-mount components, the board boasted just three microswitches – one for power on/off and one each for pump speed up and down. There were also four rectangular LEDs to indicate the pump speed.

I could see right away what the problem was – the internal tank seal had leaked and the PCB and its switches were liberally coated in a fine white powder. The seal was easy enough to fix – a new o-ring from my spare parts box soon had that sorted but the board was a real worry.

I removed it and gave it a blow out with compressed air, followed by a scrub with my fibreglass-bristle PCB brush. It cleaned up OK but the switches still looked rather dodgy. Fortunately, I had a strip of identical microswitches in stock, so I simply replaced them all and reassembled the pump.

A quick test showed it to be working OK (again, don't ask!) and the owner subsequently reported it as being as good as new. I love service work!

Faulty mixer power supply

As can be imagined, equipment reliability is critical in a TV studio. This next story from B. T. of Bonogin, Qld describes what happened some years ago when a mixer failed at a critical moment in a TV station. It also tells of the precautions they took to ensure it wouldn't happen again . . .

The old Channel 7 building at Epping in Sydney (now unfortunately reduced to rubble and replaced with an apartment complex) contained two large studios and several smaller studios. Each of the large studios was equipped with a 36-channel Neve analog (naturally) audio mixer. These were, when purchased in the early 1970s, the epitome of the audio mixer maker's art.

The 36 input channels in these mixers consisted of two modules: an amplifier/equaliser module and a switching module. All the amplifiers in these modules (and in the output modules, etc) were operated in class-A and built using discrete components, so the power requirements were substantial.

As a result, the power supply was built in the traditional English manner; that is, like a battleship. It consisted of a 6-unit rack box containing a power transformer that would not be out of place in a welder, a bank of computer-grade electrolytic capacitors and a couple of PCBs which accommodated the smaller components.

The circuit itself was a fairly traditional linear regulator that supplied 24V at 20A. The pass element consisted of six 2N3055 transistors in parallel and the circuit included over-current shutdown and over voltage protection. The front of the rack-mounting box was completely blank. There were no lights, switches, maker's name or doodads – just a military-style khaki panel. The whole thing weighed about 20kg.

The two mixers quietly went about their business for many years and everyone forgot about them until one day, about half an hour before the Sydney evening news, the mixer in the news studio suddenly went dead.

Extreme panic quickly set in and the duty technicians were called in to see if the problem could be fixed. They

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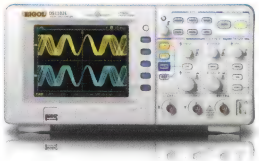

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Serviceman's Log – *continued*

Standard 8-Transistor SR-H505 Radio

P. E. of Heathcote, Victoria likes spending time out in the desert and needs to keep track of recent events and even the date. The answer to this problem was to fix an old transistor radio with shortwave bands. Here's his story . . .

I inherited a Standard 8-Transistor SR-H505 radio from my father in 1980. As far as I know, this model wasn't sold in Australia, the set in my possession having been brought back from England by my grandmother around 1960.

Somewhere along the line, the set had failed and so it sat in my shed for many years. Fortunately, the batteries (three 1.5V "D" cells) had been removed before the set had been stowed away, so there was no damage from corrosion.

This radio would have been quite expensive back in the 1960s. It was a top-of-the range 3-band unit (MW, SW1 & SW2) with two speakers and my Dad listened to it while he painted houses. He liked it because the batteries lasted quite a long time.

So why try to get this old radio going again? Well, I like to travel to remote areas in Australia from time to time and like to keep up with the news and even find out what day it is! Don't laugh, it's very easy to lose track of the days when you're out in the bush and you sometimes need to know what day it is as fuel is only available from Monday to Friday in many places.

A shortwave radio is handy when you are out in the desert, as car radios are useless in such conditions. So that's what rekindled my interest in the old Standard transistor radio.

A coin is all that's needed to undo the single screw that secures the back in place. When I did this, it was immediately apparent that the foam that's used to hold the battery pack and antenna in place had disintegrated. It was also very dusty inside the set but otherwise it was in good physical shape.

Removing the PCB wasn't going to be so easy and so before doing this, I took careful note of where the various coloured leads went and took a series of close-up photos for good measure. That done, I removed the PCB and tested all the germanium transistors after first using some old databooks to identify their base, collector and emitter leads. They all tested OK so it was time to delve further into the works.

There are lots of very small contacts in the band switch, so these were all cleaned and sprayed with WD40. It made no difference – there was still nothing from the set. In fact, there wasn't even a "crackle" when the volume control was adjusted.

Next on the list were the electrolytic capacitors and so I began testing these with my ESR and Low Ohms Meter. And that was it – the first one I tested was faulty and so were all the others.

Installing new ones was easy as they were physically smaller than the originals. This in turn meant that I could remove some parts that had originally been mounted on the copper side of the PCB and install them on the component side, since there was now sufficient room to do this. I guess there was a steep learning curve when the Japanese first starting building these "small" transistor receivers on PCBs.

This time, the radio worked but there was some crackles when the volume control was adjusted. This was fixed with some WD40 and I also did the power switch and tone control pot for good measure.

Finally, because I want to use the radio in the desert, it made sense to power it from the car's auxiliary battery. As a result, I fitted a 7805 3-terminal regulator in its battery compartment and connected this to suitable DC plug via some figure-8 cable. So the next time I'm in the desert, I'll have no trouble keeping up with the news and figuring out what day it is!

duly pulled the supply out of the rack and discovered that the pre-regulator DC was there but the regulator circuit had shut down. Unfortunately, they were unable to quickly determine why, so the news bulletin had to be cancelled, there being no spare supply and insufficient time remaining to get the working supply from the other studio.

After lugging the faulty supply back to the workshop, they fired it up and it worked, much to their surprise! Thinking that the small load they had on it may have caused this turnaround, they rigged up a load of large resistors and tried again but it still operated perfectly. They then did a few tests without finding any problems and left a note for the morning shift before going home.

The next day, there were urgent meetings and lots of worried executives and engineers. After some discussion, they decided to cancel the productions that were due in the other studio and move its working supply over to the news studio. As for me, I was given the task of fault-finding the bad supply.

I soon discovered that warming up one of the small PCBs with a hair dryer caused the supply to shut down. I also discovered that this shut-down was due to the over-voltage protection circuitry being activated.

This protection circuit was fairly brutal and consisted of a large SCR across the output. When triggered, this SCR shorted the output and caused the over-current circuit to shut off the pass transistors. If this failed (eg, if the pass transistors shorted), a large industrial strength fuse was the last resort.

No wonder that this form of overload protection was referred to as a "crowbar" circuit. It was like shorting the output with a crowbar!

Anyway, the question was why was the supply shutting down when the output was sitting on exactly 24V.

The answer was that the small circuit boards are not powered from the main supply but via a much more modest transformer. And as I discovered, a number of faulty electrolytics were allowing the reference for the over-voltage circuitry to go low. So it wasn't the main output rising that was triggering the over voltage protection. Instead, it was the reference voltage falling.

The operation of the over-current

~ A SMALL ELECTRONIC BREAST PUMP A NEIGHBOUR HAD DROPPED OFF...

circuit left a bit to be desired in that once triggered, it would latch and the only way to reset it was to switch off the mains supply and wait about five minutes for the main capacitor bank to fully discharge. If you switched it back on too soon, then it was another 5-minute wait.

We replaced the capacitors in the other supply as well and, for good measure, fitted a LED to each front panel so that we could see easily if the supply was operating. The two supplies were then installed in their respective studios and tested.

Of course, it didn't stop there. Having been caught once, the station decided that there had to be a "hot standby" supply for each studio. In addition, the news studio had to have a totally separate auxiliary mixer, in case all else failed.

The task of designing all this was given to one of the engineers and in due course a small Shure mixer appeared. Its inputs were paralleled with the main mixer and a switch allowed the studio output to come from either the main or auxiliary units.

The new supplies arrived at enormous cost and the engineer grappled with a method of switching between them, a task made more complicated by the fact that the supplies sensed the output voltage right at the mixer to compensate for any drop in the connecting cables. Getting the sensing mixed up between the two supplies would be a recipe for disaster.

In the end, he settled for a simple switch that switched the output and the sensing simultaneously between the two supplies. He also installed two mains switches that controlled the mains inputs to the supplies. This was duly demonstrated to the executives who were impressed by the fact that it was possible to switch from one supply to the other with no effect on the audio at all.

A year or so later, with all this working perfectly and no incidents of any kind, one of the audio operators got a bit bored in the quiet period before the news and decided to change supplies. He switched off the main supply and watched as the mixer went dead, then switched the DC switch to the hot standby unit which instantly shut down.

Now a whiter shade of pale, the operator powered up the original supply and switched back to this. It also instantly shut down. Panicky calls to the technicians resulted in many more switching attempts being made, all to no avail, In the end, the news was done using the auxiliary mixer.

After the news had finished, the technicians switched on both supplies and up came the mixer, good as new. They were again able to switch between supplies with no problems.

Further investigation revealed that the operator had done a completely normal test, in that it simulated what would happen if a supply really went down. Unfortunately, it transpired that if the dead mixer was then switched to a live supply, the hundreds of small electrolytic capacitors inside it drew a large spike current and triggered the over-current protection.

Of course, once triggered, a 5-minute wait was required before it would unlatch. This did not happen if the supply was not powered when it was connected to the mixer, as the circuitry brought up the voltage relatively slowly.

As a result, the engineer was brought back and the switching panel consigned to the bin. A new arrangement was devised that used diodes to connect the two supplies to the mixer, with the sensing taken from the input to the diodes. A simple relay circuit was then devised to activate an alarm if a supply failed.

This worked well, with the supply with the highest voltage running the mixer. Extensive testing proved that no combination of switching resulted in any disturbance to the mixer, unless of course they were both off. Even then, switching one on brought up the mixer perfectly.

This arrangement subsequently operated without failure until the mixers were replaced with digital mixers some 15 years later. SC

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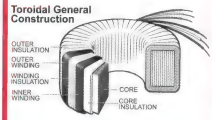

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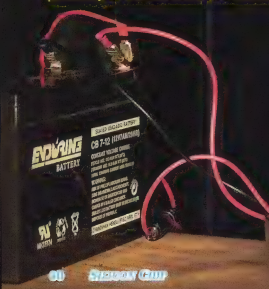
JACOB'S L

This Jacob's Ladder looks and sounds spectacular and is quite easy to build. As the high voltage sparks climb up the vertical wires they snap and snarl, almost as a warning for you to keep your distance! It even smells bad, as the purplish discharge generates ozone.

Never mind the photo, SEE and HEAR how the Jacobs' Ladder performs by logging on to our website at siliconchip.com.au/videos/jacobsladder. This short video clip shows how the spark climbs up the wires to the point where it is extinguished and then it starts again at the bottom to repeat the process. It makes quite a lot of noise and does generate ozone. Mind you, while you might expect that it would generate lots of RF interference to radio reception, in practice it does not appear to be a problem, unless you have a radio in very close proximity to the unit when it is operating.



We described our last Jacob's Ladder project in the April 2007 and it is still a popular project. But when we recently presented the new High Energy Ignition Module in the November & December 2012 issues, we realised that it would make an ideal Jacob's Ladder driver and that it should have even more zing and zap than the April 2007 design. And so it has proved to be.

By the way, we are aware that there are a number of mains-power Jacob's Ladder circuits on the internet. **These are very dangerous and could easily be lethal. Don't even consider building one of those. Build ours.**

That's not to say you won't get a helluva belt off ours if you're silly enough to touch the bitey bits when it's running. But at least you'll be able to learn from your mistake – you may not get that chance with a mains-powered type.

Ignition module variant

In essence, the Jacob's Ladder presented here is a slight variation on the version which can be used as a self-contained ignition coil tester. Its frequency can be varied up to 75 sparks per second and the "dwell" setting can be used to vary the timing to obtain the best sparks, ie, the noisiest and most nasty!

Now we are are not going to reproduce all the information on the High Energy Ignition module – if you want to read that you should refer to the November and December 2012 issues.

Instead, we will give all the information which is relevant to this particular variant.

So let's have a look at the circuit of Fig.1.

Microcontroller IC1 is the heart of the circuit. It drives the gate of the IGBT (insulated gate bipolar transistor), Q1. These IGBTs are used by the squillion in the ignition system of modern cars. This type of IGBT is a big improvement on the high voltage transistors used in our previous ignition systems and it can be driven directly from the output of the microcontroller via a 1kΩ resistor from pin 9 (RB3). As a result, the circuit is more efficient and very little power is dissipated.

In operation, IC1's RB3 output is alternatively switched high (to +5V) and low to turn Q1 on and off. Each time Q1 is turned on, the current builds up in the primary winding of the coil and this stores energy in the resulting magnetic field.

This magnetic field collapses when when Q1 turns off and it induces a very large voltage in the secondary winding, to fire the spark plug, or in our case, to cause a big spark to jump

By LEO SIMPSON

JACOB'S LADDER

What is a Jacob's Ladder?

Jacob's Ladder has its origins in three major religions – Christianity, Judaism and Muslim (we try to please all readers . . .). Jacob, the son of Abraham, dreamed about a "ladder" between earth and heaven with angels climbing up and down. Some references have this ladder made from flames and sparks – hence the electronic version doing the same thing. OK, no flames – but plenty of mean-sounding sparks! Physically, as our photos show, it has two parallel (or near-parallel) metal rods about 300mm long and about 30mm apart, which have such a high voltage between them that sparks jump from one to the other. As the spark is hot, the surrounding air is heated. Hot air rises, so the column of rising air pushes the sparks upward so that they appear to form the "rungs" of a ladder.

across the high voltage terminals of the ignition coil.

Incidentally, in the past, most ignition coils have been auto-transformers meaning that the primary and secondary windings are connected together at one end. However, many modern ignition coils are true transformers, with completely separate primary and secondary windings.

The particular ignition coil we are using for the Jacob's Ladder is from a V8 series Holden Commodore. These can usually be purchased from a wrecker or via ebay (which is where we got ours). We paid $27.50 including postage.

Apart from being a readily available high energy ignition coil, the Commodore unit has a further advantage in that it has two high voltage terminals and these normally drive two spark plugs in series when used in the Commodore V6 engine.

In our case, the two high-voltage terminals make it very suitable for a Jacob's Ladder. Just connect a stiff wire to each terminal and it's done. Now back to the circuit description.

In operation, IC1 monitors two separate voltages, at pin 1 & 18.

The dwell period and spark rate are set by trimpots VR1 and VR2, each connected across the 5V supply. VR1 (dwell) is monitored by input AN1 (pin 18), while VR2 (frequency) is monitored by input AN2 (pin 1).

The dwell is adjustable from 129µs to 26ms and is set by monitoring the voltage at TP1. However, this is not necessary. In practice, you simply tweak VR1 to give the "hottest" (ie, best looking!) spark discharge.

We are using the coil/spark test mode of the software for the High Energy Ignition module.

In the original circuit (November 2012) this was selected

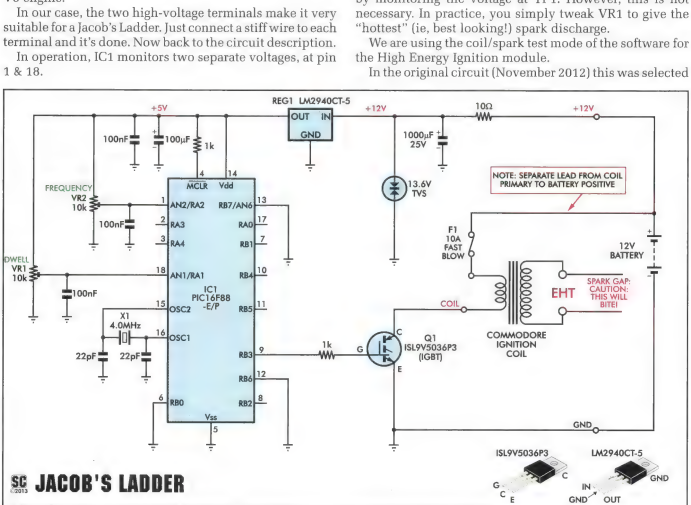
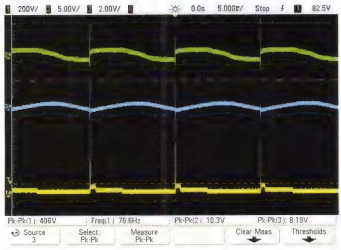
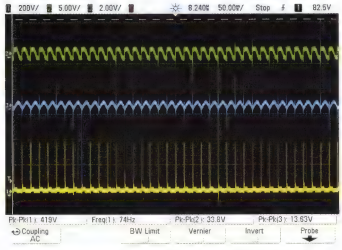


Fig.1: the circuit incorporates additional components to protect the regulator against peak voltages which are superimposed on the positive supply line from the battery.



This scope grab shows the Jacob's Ladder circuit running at 76 sparks/second and a sweep speed of 5ms/div. The yellow trace shows the high voltages (around 400V peak) at the collector of the IGBT, while the green trace shows the fluctuation on the positive battery rail. The blue trace is the voltage across the transient voltage suppressor (TVS), showing that it is doing its job of protecting the regulator.



This shows the same waveforms as Scope1 but with the sweep speed slowed to 50ms/div. This capatures more of the spike voltages on the supply lines. Without the input protection components, these spike voltages would be a great deal higher and would damage the regulator. Note that the spike voltages differ because each spark discharge takes a different path across the gap.

with LK2 (connected to pin 12 of IC1). Since we don't need link options, the Jacob's Ladder version of the circuit merely has pin 12 connected to 0V, to achieve the same outcome.

Trimpot VR2 is used to set the spark rate, with a range of 15-75Hz (clockwise for increased frequency).

IC1 is powered from a regulated 5V supply derived using REG1, an LM2940CT-5 low-dropout regulator designed specifically for automotive use. It features both transient overvoltage and input polarity protection.

However, even though the LM2940CT-5 is a rugged regulator, it needs protection from the very high transient voltages which can be superimposed on the +12V line from the battery.

Hence, we have incorporated extra protection with the 10Ω series resistor and the 13.6V transient voltage suppressor (TVS). It clamps transient voltages to around 23V, a safe level for the regulator. As well, we have included a 1000µF 25V capacitor to provide further filtering for the input to the regulator.

Even so, it is most important that the +12V line to the module must be a separate wire to the battery positive terminal, as shown on the circuit. We have added these components after twice blowing the regulator and the microcontroller while having fun (um, doing important research) with our prototype Jacob's Ladder.

REG1 also has a 100µF filter capacitor at its output, required for stable operation.

By the way, note that word "battery". Don't even think about running this from a mains supply. A 12V SLA (sealed lead-acid) battery, as shown in the first photograph, is perfect for this project and will not only give a long operation time, it can be disconnected and recharged for the next zap!

For longest life you could run this from a 12V car battery but they are rather heavy and difficult to lug around. And they can be messy.

Building it

The Jacob's Ladder module is built on the same PCB as the ignition system, coded 05110121 and measuring 89 x 53mm. This is housed in a 111 x 60 x 30mm diecast aluminium case to give a rugged assembly.

A cable gland at one of the case provides the cable entry points for the positive and negative leads from the 12V battery and the lead from the IGBT's collector to one of the primary connections on the Commodore ignition coil.

There are significantly less components required for the Jacob's Ladder;

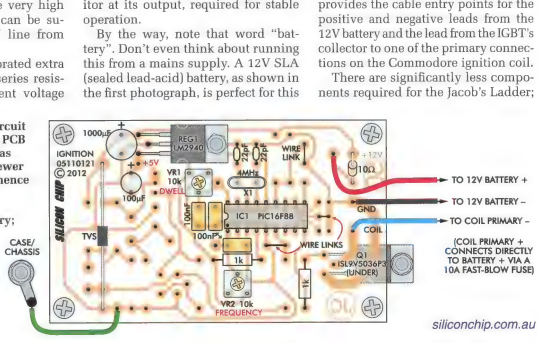
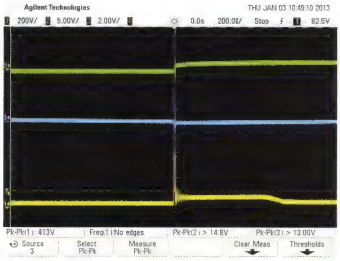
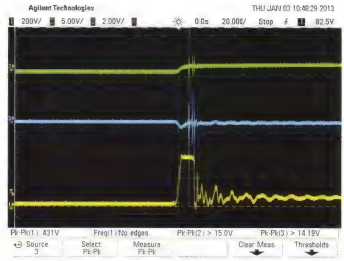


Fig.2: the Jacob's Ladder circuit uses the electronic ignition PCB (from November 2012) but as you can see, significantly fewer components are required (hence the empty holes). Note the wiring connection for the + side of the coil primary; it connects directly to the battery + terminal via a fuse. Don't be tempted to run the PCB wiring from this fuse. Keep the wiring separate.



Again, same waveforms as before but with sweep speed upped to 200µs/div. Here see the ringing of the coil primary after the main spike. The voltage is clipped to 413V by the protection limiting inside the IGBT.



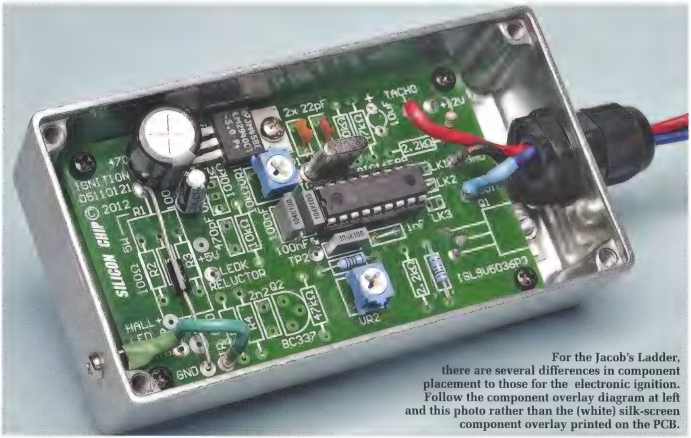
Same conditions as the grab at left but with sweep speed upped again to 20µs/div. Here we see that the spike voltages across the supply lines are very fast and both are actually clipped by the scope.

hence large areas of the PCB are unpopulated.

The first step is to check the PCB for any defects and in the unlikely case that there are any defects, fix them. Then install the components shown in the diagram of Fig.2. If you are using a PCB supplied by SILICON CHIP, Altronics or Jaycar you will find that some of the components to be installed are not as indicated on the silk-screened component layout on the top of the PCB itself.

For example, the red wire from the positive terminal of the battery does not connect to the +12V pin at the top right-hand corner of the PCB. Instead it connects to the PC pin marked "Tacho" which is not being used for its original function in this Jacob's Ladder version of the circuit. We will detail the other component variations as we go through the assembly procedure.

Begin the assembly by installing the four PC stakes at the external wiring points, ie, Tacho, GND, COIL, and TP GND. Then install three short wire links. One goes in the position labelled LK2 at one end of the microcontroller, another is wired in the position for the



For the Jacob's Ladder, there are several differences in component placement to those for the electronic ignition. Follow the component overlay diagram at left and this photo rather than the (white) silk-screen component overlay printed on the PCB.

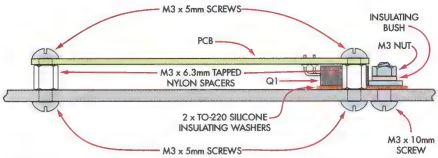
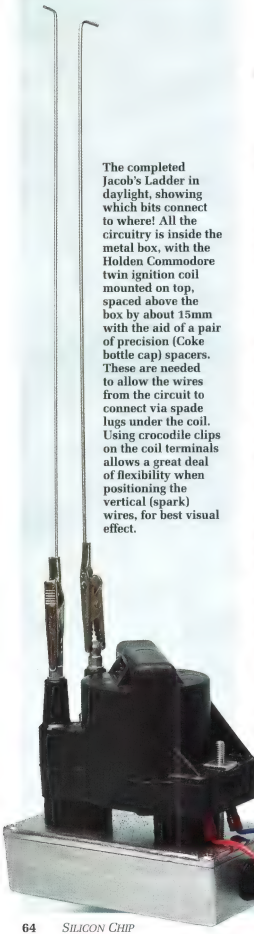


Fig.3: here's how the IGBT is mounted underneath the PCB. 6.3mm Nylon spacers hold the PCB at the right height and also insulate it from the case. Two silicone insulating washers are used to insulate the IGBT from the case.



The completed Jacob's Ladder in daylight, showing which bits connect to where! All the circuitry is inside the metal box, with the Holden Commodore twin ignition coil mounted on top, spaced above the box by about 15mm with the aid of a pair of precision (Coke bottle cap) spacers. These are needed to allow the wires from the circuit to connect via spade lugs under the coil. Using crocodile clips on the coil terminals allows a great deal of flexibility when positioning the vertical (spark) wires, for best visual effect.

1nF capacitor adjacent to the pins 5, 6 & 7 (of the microcontroller) while the third replaces the 10µF capacitor near the original "TACHO" PC stake. These can followed by the three resistors.

Follow with the IC socket, making sure it is orientated correctly but don't install the PIC micro yet.

The capacitors can go in next. Orientate the two electrolytics as shown) then install crystal X1 and trimpots VR1 & VR2. The TVS can be installed either way around as it is not a polarised device.

Regulator REG1 can then go in. Be sure to fasten REG1's tab to the PCB using an M3 x 10mm machine screw and nut before soldering its leads.

IGBT mounting details

Fig.3 shows the mounting details for IGBT transistor Q1. It's secured to the base of the case, with its leads bent at right angles and passing up through the underside of the PCB.

For the time being, simply bend Q1's leads upwards through 90° and test fit it to the PCB but don't solder its leads yet. Its tab mounting hole must be clear of the edge of the PCB, as shown in the diagrams.

Then fit the PCB assembly inside the case and slide it to the left as far it will go, to leave room for Q1. The mounting hole positions for the PCB and Q1's tab can then be marked inside the case, after which the PCB can be removed and the holes drilled to 3mm (hint: use a small pilot drill first).

Deburr these holes using an oversize drill. In particular, Q1's mounting hole must be slightly countersunk inside the case to completely remove any sharp edges.

The transistor's mounting area on the case should also be carefully smoothed using fine emery paper. These measures are necessary to prevent the insulating washers which go between Q1's metal tab and the case from being punctured by metal swarf or by a high-voltage arc during operation.

Having drilled the base, the next step is to mark out and drill the hole in the case for the cable gland. This hole is centrally located the end of the case at which the IGBT is mounted. It should be carefully reamed to size so that the cable gland is a close fit.

You will also have to drill a 3mm hole for the earth connection in the other end of the case – see photos.

Installing the PCB

Once the case has been drilled, fit 6.3mm tapped **Nylon** stand-offs to the PCB's corner mounting holes using M3 x 5mm machine screws.

That done, the next step is to fasten Q1 in place. As shown in Fig.3, its metal tab is insulated from the case using two TO-220 silicone washers and an insulating bush and it's secured using an M3 x 10mm screw and nut.

Do this screw up finger-tight, then install the PCB in the case with Q1's leads passing up through their respective mounting holes.

The PCB can now be secured in place using four more M3 x 5mm machine screws, after which you can firmly tighten Q1's mounting screw (make sure the tab remains centred on the insulating washers).

Finally, use your multimeter to confirm that Q1's tab is indeed isolated from the metal case (you must get an open-circuit reading), then solder its leads to the pads on top of the PCB.

External wiring

All that remains now is to run the external wiring. You will need to run three leads through the cable gland

and solder them to the relevant PC stakes for the power, coil and input trigger connections. Don't be tempted to use mains cable for the three leads – brown, blue and green/yellow should never be used for anything but mains.

The earth connection from the PCB goes to an solder lug that's secured to the case using an M3 x 10mm screw, nut and star washer.

Initial checks & adjustments

Now for an initial smoke test – apply power to the unit (between +12V and GND) and use your DMM to check the voltage between the +5V PC stake and GND. It should measure between 4.85V and 5.25V. If so, switch off and insert the programmed PIC (IC1) into its socket, making sure it goes in the right way around.

You can now do some more tests by connecting the car's ignition coil between the +12V battery terminal via a 10A in-line fuse. The unit should be powered from a 12V car or motorcycle battery or a sealed lead acid battery, **NOT from a mains power supply.**

The negative coil wire (shown in blue on the diagram) connects to the "coil" terminal on the PCB.

Before connecting the +12V power, set the dwell trimpot (VR1) fully anticlockwise. Then apply power and slowly adjust VR1 clockwise. The sparks should start and gradually increase in energy with increased dwell. Stop adjusting VR1 when the spark energy reaches its maximum.

You can also set the spark frequency using VR2 but we found the best result was with it set to maximum, ie, clockwise.

Mounting the Commodore ignition coil

We mounted the Commodore ignition coil onto the lid of the case using two M3 bolts and nuts.

Since the two primary connection are recessed underneath the coil, we had to space it off the lid of the case and we used two PET soft drink bottle lids for this. Brand is unimportant – just make sure you don't use metal caps!

We made the connections to the coil primary with red crimped male spade connectors (Jaycar PT-4518).

Finally, we fitted a pair of crocodile clips with screws (Jaycar HM-3025) with stiff wire, about 250mm long.

You can dispense with the plastic finger grips since the sparks jump between the crocodile clips and then climb the wires.

Note how the clips fasten to the coil terminals in our photos – if you mount them the other way (ie, with the bodies closer together) you'll probably find that the sparks jump across the crocodile clips but don't climb up the wires.

In fact, you'll probably have to experiment somewhat with the wire positions to get the climbing action reliable.

We found that very close to parallel was right. We also bent the top 10mm or so of the wires away from the ladder, as you can also clearly see in the pic.

Want to use taller wires? Give it a go – but if they are too tall it becomes unwieldy.

Fitting a "chimney"

We also experimented with a clear plastic (acrylic?) tube over the whole ladder. This has the added advantage of creating a vertical airflow as the air inside the tube heats up. This adds to the rising spark effect.

The biggest problem was finding a clear tube (a) big enough – it needs to be about 150mm inside diameter and (b) cheap enough to warrant its use. In the end, being somewhat tight in both the wallet and time departments, we gave the idea away!

However, if you can find such a tube it will add to the spectacle and should also assist the spark if there is any form of breeze. We found wind impedes the climbing effect. The tube needs to be open-ended top and bottom to create the draught.

An acrylic tube will also assist somewhat in keeping the zaps contained – but don't rely on it! A thick acrylic tube should have hundreds of kilovolts of insulation but you can never be sure. The moral of the story is, keep your fingers (and anyone else's!) away from the vertical wires.

Before making any adjustments – moving the wires for a better display, for example – disconnect the battery and make sure gravity or any other force cannot accidentally make a connection when you don't want it to!

As we said earlier, accidentally touching the wires while in operation (why would anyone touch them deliberately?!!) will certainly give you some energy you didn't know you had – and may even (perish the thought!) cause you to issue forth with naughty words!

Parts list – Jacob's Ladder

1 VS Commodore ignition coil (source from a wrecker or ebay)
1 PCB, code 05110121, 89 x 53mm
1 diecast aluminium case, 111 x 60 x 30mm (Jaycar HB5062)
1 cable gland to suit 3-6mm cable
1 transistor insulating bush
2 TO-220 3kV silicone insulating washers (Jaycar, Altronics)
1 4MHz HC-49 crystal (X1)
1 18-pin DIL IC socket
1 in-line 3AG fuse holder and 10A 3AG fuse (fast-blow)
1 solder lug
2 crocodile clips with screws (Jaycar HM-3205)
2 250mm lengths approx. 1.5mm diameter steel wire
2 red crimp spade lugs (Jaycar PT-4518)
4 6.3mm tapped Nylon standoffs
8 M3 x 5mm screws
3 M3 x 10mm screws and nuts
2 M3 x 30mm screws and nuts
1 M3 star washer
4 PC stakes
1 500mm length of red automotive wire
1 200mm length of black automotive wire
1 200mm length of blue automotive wire

Semiconductors

1 PIC16F88-E/P microcontroller programmed with 0511012A.hex (IC1)
1 ISL9V5036P3 ignition IGBT (Q1) (X-On: [illegible])
1 LM2940CT-5 low drop out 5V regulator (REG1) (Altronics Z0592, Jaycar ZV1560)
1 13.6V transient voltage suppressor (TVS) (Jaycar ZR-1175)

Capacitors

1 1000µF 25V PC electrolytic
1 100µF 16V PC electrolytic
3 100nF MKT (code: 104)
2 22pF ceramic (code: 22)

Resistors (0.25W 1%)

2 1kΩ (code: brown black black brown or brown black red brown)
1 10Ω (code: brown black black gold brown or brown black black brown)
2 10kΩ mini horizontal trimpots (VR1,VR2)

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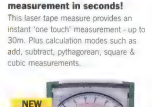

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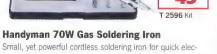

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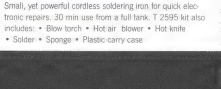

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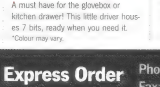

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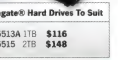

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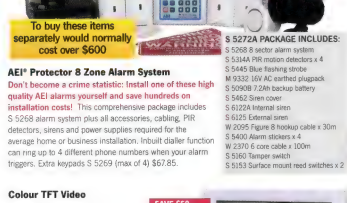

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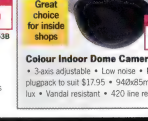

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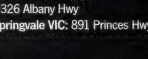

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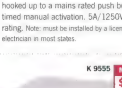
K 6047



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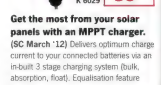

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CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

10Hz-100kHz Function Generator Uses MiniMaximite Display

Jack Holliday is this month's winner of a $150 gift voucher from Hare & Forbes

This circuit (Fig.1) uses an ICL-8038 waveform generator to produce sine, triangle and square wave outputs. The 8038 chip can still be obtained over the internet for just a few dollars each. A MiniMaximite is used as an embedded controller to display the frequency, period, output voltage and frequency band on a 16x2 LCD panel.

The frequency of oscillation is controlled by the value of the capacitor connected to pin 10 and the values of the resistance from pins 4 and 5 to the positive supply. The resistance between pins 4 and 5 and the sweep supply is adjusted using VR2 to give a 50% duty cycle. If the duty cycle is not 50%, the peaks on the sinewave output will appear to lean forwards or backwards.

Four frequency bands provide a total range of 10Hz to 100kHz. Band 1 is 10-100Hz, band 2 is 100-1000Hz, band 3 is 1 kHz-10kHz and band 4 is 10kHz-100kHz, with each band having a small overlap with neighbouring bands. The bands are selected using switch S1a to connect capacitors of different values to pin 10. Switch S1b is a voltage divider connected to pin 2 of the MiniMaximite.

Trimpots VR3 and VR4 control sinewave distortion. With careful adjustment of VR2, VR3 and VR4, a sinewave distortion level of 1% is achievable.

The sine and triangle wave outputs are buffered by op amps IC1b & IC1a and their gains have been selected to give the same amplitudes for both waveforms of about 10V peak-to-peak output.

The 8038 also has a square-wave output but it was not used as the square-wave source, for two reasons. First, the output at higher frequencies was not a good square wave. And second, the data sheet warns that using the square-wave output can cause glitches to appear on the sine and triangular outputs. Instead, the buffered sinewave output is squared up using a 4049 hex inverter.

The sine, triangle and square-wave outputs are connected to switch S2 and then fed to VR5a, the level control. This feeds IC3, an LM6171 wide bandwidth, high slew rate op amp. The 4.7kΩ resistor in series with pin 2 limits the bandwidth somewhat to provide less overshoot on square wave signals.

VR5b tracks the position of level control VR5a and is used by the MiniMaximite to provide an approximate measure of the output level chosen. This information is displayed on the LCD panel.

The square wave output from IC2b is fed to pin 11 of the MiniMaximite. Pin 11 is configured to measure frequency and this information, along with the period, is displayed on the LCD. Three significant figures are displayed for frequency on all ranges except band 1 where two significant figures are used. The 3.3V zener diode ensures that the input voltage to the MiniMaximite does not exceed a safe level.

To set up, adjust VR2 for 50% duty cycle as described earlier, then adjust VR3 and VR4 for best sinewave output.

Jack Holliday,
Nathan, Qld.

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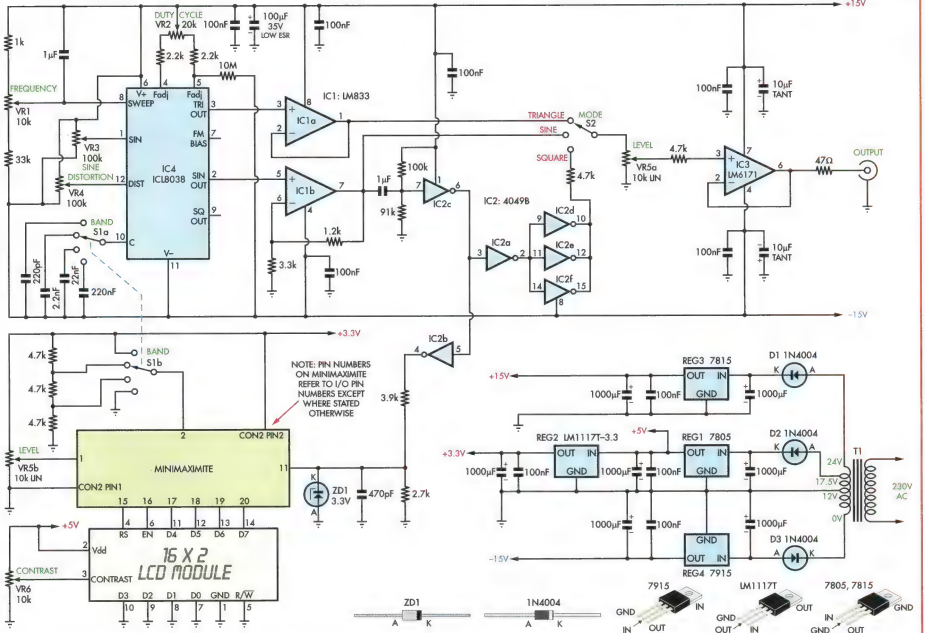
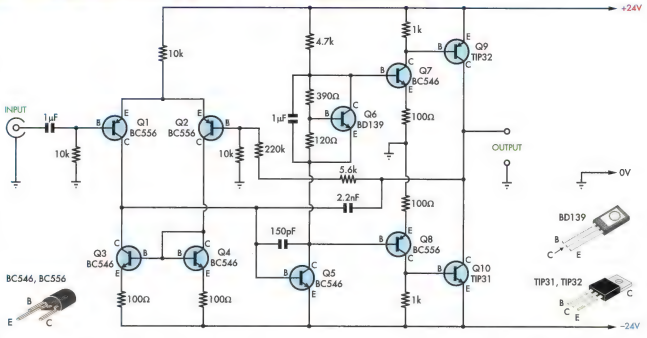


Fig.1: the circuit uses an ICL8038 waveform generator to produce sine, triangle and square-wave outputs, while a MiniMaximite is used as an embedded controller to display the frequency, period, output voltage and frequency band on a 16x2 LCD panel.



Rail-to-rail power amplifier for non-audio use

This analog amplifier was designed to drive a brushless motor in environments where low EMI is critical (rather than using a typical switch-mode design) but could have a variety of applications. Essentially, it is a simplified Class-B audio amplifier which has been modified to provide better efficiency and to maximise output power from limited supply rails by allowing the output to swing over virtually the full supply range.

The input signal is coupled to the base of one of the PNP differential input transistors (Q1) via a 1µF capacitor and 10kΩ bias resistor. It can be DC-coupled too but this arrangement allows you to run it from a single supply (eg, 48V DC) with the control signal referenced to ground or some other rail using a suitable rail splitter (to give a virtual ground).

The differential input pair has the standard configuration but rather than use a constant current source, their emitters are simply tied to the positive rail via a 10kΩ current-limiting resistor. This would normally be unacceptable for audio since it introduces some extra distortion but in this type of application, that is unimportant.

The current mirror formed by NPN transistors Q3 and Q4 automatically balances the current through Q1 and Q2 and this improves (among other attributes) supply rejection, which may be important, depending on the stiffness of the supply.

This input stage then drives Q5 (part of the "voltage amplification stage" or VAS) which has a 150pF Miller capacitor for stability. In an audio amplifier we would normally use another constant current source as its collector load for best linearity but we have again simplified that down to a single 4.7kΩ resistor.

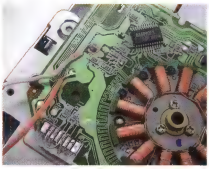
Between the two is Q6, another NPN transistor configured as a V_{BE} multiplier which is used to bias the output stage. It is shown with fixed resistors to set the voltage across it but in practice, a trimpot would be used as it could then be adjusted to compensate for component variation and so on. A 1µF capacitor across this stage reduces the variation in bias voltage with output voltage because of the varying current through this stage during operation.

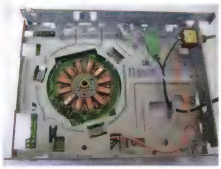
The output stage is a little unusual and departs from typical Class-B practice. To get maximum swing, the transistor sourcing current into the load (Q9) must be a PNP type and the one sinking current from it (Q10) must be NPN; the opposite to that used in a typical Darlington-type output configuration. These are driven by small signal transistors which have opposite polarity, effectively forming complementary pairs, but not in the way that such pairs are typically used in amplifiers.

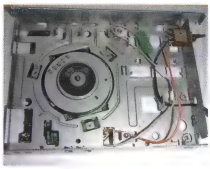
To swing the output positive, the input stage reduces drive to VAS transistor Q5 and thus the 4.7kΩ resistor pulls up the bases of Q7 and Q8. This turns Q7 on harder and reduces the drive to Q8. Q7 then pulls more current from the base of Q9, turning it on harder and sourcing current to the load. With Q8 turning off, so does Q10 and thus there is relatively little flow current from Q9 to Q10 (ie, quiescent current). This quiescent current is adjusted using the V_{BE} multiplier trimpot, as usual.

The 100Ω emitter resistors for Q7 and Q8 provide some local negative feedback which is critical for stability; for example, as Q7 turns on and sinks more current from Q9's base, the voltage across its emitter resistor increases and so limits the amount of current sunk from Q9, preventing it from turning on too rapidly. These resistors also help to make the quiescent current adjustment less sensitive, for the same reason.

The 1kΩ resistors between base and emitter of Q9 and Q10 speed up their turn-off and reduce their collector-emitter leakage when the other half of the amplifier is in full conduction.







Recycling a floppy drive for use as a mini polishing machine

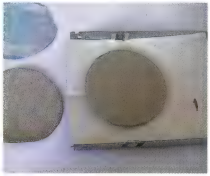
Floppy drives are now seldom used but they can easily be recycled from old computers. I have recycled a floppy drive and now it works as a mini grinding and polishing machine for various small parts.

Any floppy drive can be used and the first step is to disassemble it. Inside, you will see the board and the asynchronous motor on it. You can throw out all superfluous components except the board and the motor.

On the board there is typically a BA699* chip (in my case, a BA6992) which has a 2-5-channel power driver (with internal thermal shutdown). You must short-circuit pins 1 & 16 and connect them to GND, then short-circuit pins 13 & 19.

Pin 21 of the BA6992 is Vcc, while pin 9 is GND. Power supply voltage is about 5-9 V (from a 7809 regulator or similar). Current consumption is up to 350mA. You will need to fit a power switch. If the modifications have been done correctly, the motor will run immediately at switch on.

The strength of rotation is sufficient for grinding and polishing various small parts. For grinding, paste a circular piece of emery paper onto the rotor. For polishing, use a piece of closely woven fabric to which you can apply paste. The photos show the various steps in this process.



Note that you cannot use your polishing machine continuously. Stop every 15 minutes or to prevent overheating of the BA6692.

Alexey Uskov,
Vladivostok, Russia. ($50)

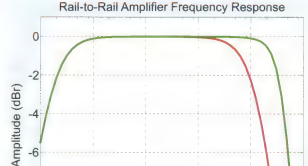
SPICE simulation shows that the extra gain in this rail-to-rail output stage makes a typical amplifier unstable regardless of the value of the Miller capacitor. So to make it stable, we are using nested feedback. This is achieved by adding the 2.2nF capacitor from the output back to the base of Q5, the VAS transistor. This provides some roll-off in the frequency response of the VAS/output stage but it does not affect global feedback as it bypasses the input stage.

While the value of this capacitor does not appear to be especially critical, its presence definitely is; simulation shows bad oscillation if it is removed. The 2.2nF value was chosen for operation at around 1kHz and if, for example, you wanted to use this amplifier to drive an ultrasonic transducer, you would need to reduce its value somewhat. At around 820pF, operation beyond 20kHz is quite feasible and the circuit still appears to be stable.

Gain is set to 23.5 by the feedback divider, so that a 2V peak-to-peak input signal will give a full output swing with a ±24V or 48V supply. This can be altered to suit the application.

The parts shown were chosen for relatively low power use (driving a ~16Ω load) but larger transistors could easily be used as long as they have sufficiently high h_{FE}. In most applications, heatsinking will be required for Q9/Q10 and possibly also Q7/Q8, which might need to be changed to higher-power devices (eg, BD139 and BD140). Q6 would normally also be mounted on the heatsink to avoid thermal runaway.

Nicholas Vinen,
Silicon Chip.



SPICE frequency response plot for the amplifier using two different values of nested feedback capacitors. This doesn't tell the whole story though as the amplifier runs into slew rate limiting before it runs out of bandwidth. The practical bandwidth is around 7kHz with 2.2nF and 20kHz with 820pF.

Extremely accurate GPS 1pps timebase for a frequency counter

Get maximum accuracy from your 12-Digit Frequency Counter using this GPS 1pps Timebase. It connects to the external timebase input of the counter and will let you achieve measurement accuracy close to that of an atomic clock. You can either build it into the frequency counter or use it as a separate module.

By JIM ROWE

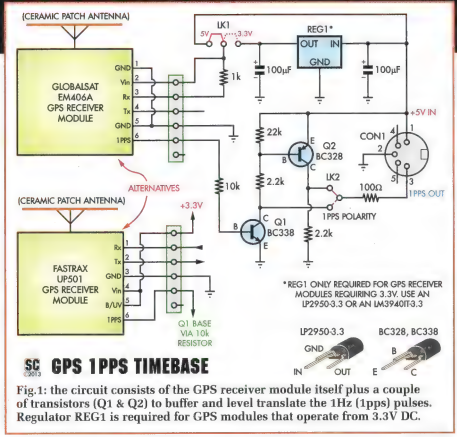


Fig.1: the circuit consists of the GPS receiver module itself plus a couple of transistors (Q1 & Q2) to buffer and level translate the 1Hz (1pps) pulses. Regulator REG1 is required for GPS modules that operate from 3.3V DC.

ARE YOU KEEN to build the new 12-Digit High-Resolution Frequency Counter described in the December 2012 and January 2013 issues of SILICON CHIP? It's a world-first DIY design but you will also want to get the very best accuracy to go with its 12-digit resolution.

To do this, you don't need our complex GPS-based Frequency Reference (SILICON CHIP, March-May 2007), although this can be used if you have it. If you don't, then there's a much simpler and cheaper approach: purchase a cheap GPS receiver with 1pps output, bung it on a small interface PCB and you get close to atomic clock precision.

In fact, we promised in our January 2013 issue to publish such a device and here it is. Build it for your frequency counter and you should be able to achieve a measurement accuracy of around ±1 part in 10^{11}!

Simple circuit

Fig.1 shows the circuit details. It looks simple but that's because all the complex circuitry needed to receive the signals from the GPS satellites and derive the 1Hz (1pps) pulses is inside the GPS module.

We are specifying either of two GPS modules which are currently available from various suppliers: the GlobalSat EM-406A module which is currently available for as little as $39.90 or the Fastrax UP501 module which is smaller but priced at $59.90. The project is also compatible with various other receiver modules, if you find the EM-406A or the UP501 hard to get.

The type of GPS receiver module you'll need is one that incorporates its own ceramic "patch" antenna for the UHF signals from the GPS satellites, while also providing an output for 1pps (pulse per second) time pulses. It can operate from a DC supply of either 5.0V or 3.3V. A few currently available modules are listed in a panel elsewhere in this article.

The EM-406A has its own built-in GPS patch antenna and operates

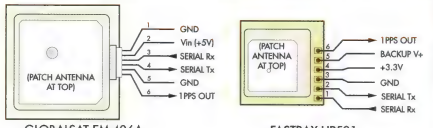


Fig.2: the pin connections for the GlobalSat EM-406A and Fastrax UP501 GPS modules. Check the pin connections if you use a different module.

directly from 5V DC. It features the SiRF Star III high-performance GPS chipset, very high sensitivity and an extremely fast time to first fix (ie, from a cold start).

The UP501 and other compatible GPS modules operate from 3.3V DC, so for these we have made provision for fitting a 5V-3.3V LDO (low dropout) regulator (REG1). You can use either an LP2950-3.3 regulator which comes in a TO-92 package or an LM3940IT-3.3 which comes in a TO-220 package.

Apart from the power supply arrangements, there is a simple buffer and level translator for the 1Hz pulses provided by the GPS module. This uses transistors Q1 (a BC338) and Q2 (a BC328) to ensure that the 1Hz pulses fed out to the counter have a peak-to-peak amplitude of 5V, regardless of the supply voltage used by the GPS module.

Link LK2 allows the 1Hz pulses to be inverted or not by the buffer, so that their "leading edges" are positive-going regardless of their polarity out of the GPS module (some modules may output them as inverted.)

Why do we need to ensure that the leading edges of the 1Hz pulses fed to the 12-Digit Frequency Counter are positive-going? Simply because it's the leading edges of the pulses that are locked closely to the "atomic time" provided by the GPS satellites. The counter uses the positive-going edges of the external timebase pulses to clock its main gate flipflop, so this ensures the highest measurement accuracy.

Assembly

All the parts fit on a PCB coded 04103131 and measuring just 66 x 46mm. Fig.3 shows the assembly details. Almost half of this tiny PCB is reserved for the GPS module itself which is usually mounted using double-sided adhesive foam.

To allow for convenient connection back to the counter when it is being used remotely, we have provided space for a 5-pin mini-DIN socket (CON1) at the righthand end of the PCB. This allows you to use a cable fitted with a 5-pin DIN plug to link the GPS timebase back to the counter, at the same time providing the unit with +5V power.

This socket is not needed if the PCB is fitted inside the 12-Digit Frequency Counter's case. In this situation, the

Parts List

1 PCB, code 04103131, 66 x 46mm
1 GPS receiver module with in-built patch antenna & 1pps output
1 6-way SIL pin strip
2 3-way SIL pin strips
2 jumper shunts
4 M3 x 10mm untapped Nylon spacers*
4 M3 x 25mm Nylon screws*
8 M3 nuts
Hook-up wire for GPS module
25 x 25mm doubled-sided adhesive foam (to secure GPS module)

Semiconductors

1 BC338 NPN transistor (Q1)
1 BC328 PNP transistor (Q2)
1 LP2950-3.3 (TO-92) or LM3940IT-3.3 LDO regulator**

Capacitors

1 100µF 16V RB electrolytic (or 2 if a 3.3V supply required)

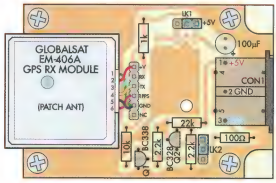
Resistors (0.25W, 1%)

1 22kΩ 1 1kΩ 1 100Ω
1 10kΩ 2 2.2kΩ

*Only if project is built inside the frequency counter
**Only for a GPS module which requires a 3.3V supply

Extra parts for jiffy box version

1 UB-5 jiffy box, 83 x 54 x 31mm
1 5-pin DIN socket, PCB-mount (Altronics P1188, Jaycar PS0350)
1 5-pin DIN socket, panel mount, for frequency counter (Altronics P1178, Jaycar PS0348)
2 5-pin DIN plugs (Altronics P1150, Jaycar PP0304)
1 2-core shielded cable (Altronics W3020, Jaycar WB1504)
4 M3 x 10mm machine screws



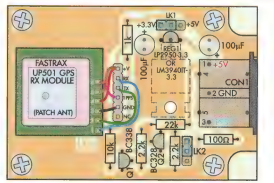


Fig.3: follow these two diagrams to build the GPS 1pps Timebase. Omit CON1 if the unit is to go inside the frequency counter's case and omit REG1 and its 100µF output capacitor if the GPS module uses a 5V supply, eg the GlobalSat EM-406A. Alternatively, fit REG1 and the 100µF capacitor for the Fastrax UP501. Don't forget to set link LK1 accordingly.

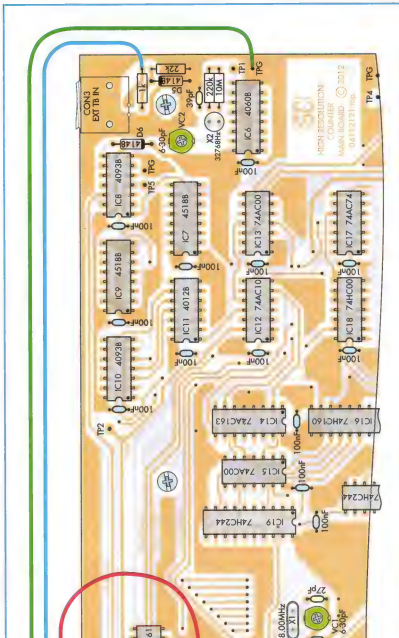


Fig.4: only three leads are required to connect the timebase module to the main PCB in the frequency counter. These leads are connected directly to the GPS timebase board if it is mounted inside the counter case or run to a panel-mount DIN socket (installed on the counter's rear panel) if the GPS timebase is mounted in a separate case (see panel).

Compatible GPS Modules

The following GPS receiver modules should be compatible with this unit:

- GlobalSat EM-406A: 30 x 30 x 10.5mm including patch antenna. Operates from 5V DC with a current drain of 44mA. Provides a 1pps output plus a "fix" indicator LED. Rated sensitivity -159dBm.
- Digilent PmodGPS: approximately 30 x 55 x 12mm including patch antenna. Operates from 3.3V DC with a current drain of 24/30mA. Provides a 1pps output plus a "fix" indicator LED. Rated sensitivity -165dBm.
- RF Solutions GPS-622R: 43 x 31 x 6mm including patch antenna. Operates from 3.3V DC with a current drain of 23/50mA. Provides a 1pps output plus a "fix" indicator LED. Rated sensitivity -148dBm/-165dBm.
- Fastrax UP501: 22 x 22 x 8mm including patch antenna. Operates from 3.3V DC with a current drain of 23mA. Provides a 1pps output. Rated sensitivity -165dBm.

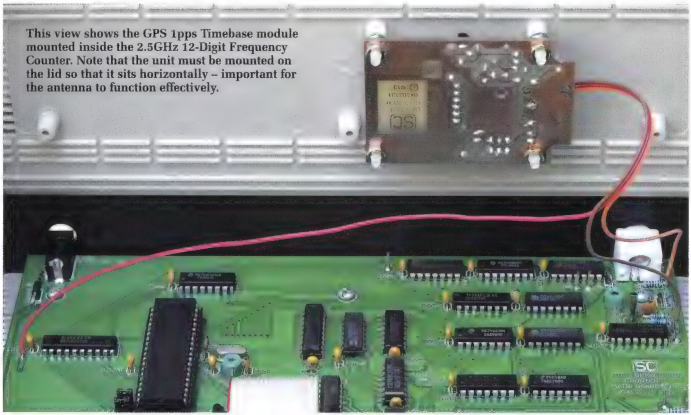
Note that for use in this project, the GPS receiver module should have a built-in ceramic patch antenna and also provide an output for the GPS-derived 1Hz pulses. Not all GPS modules currently available provide both these features.

GPS PCB is linked to the counter's main PCB using three short lengths of insulated hook-up wire.

Two other components shown in Fig.3 are required only if your GPS module needs a 3.3V DC supply, rather than 5V. These are REG1 and the 100µF electrolytic capacitor connected between its output and ground. **If you are using the EM-406A module (which requires 5V) and you are also mounting the receiver inside the counter box, leave out CON1, REG1 and the 100µF capacitor. Conversely, install REG1 and the 100µF capacitor if you are using the UP501 GPS module.**

As previously stated, LK2 must be fitted in the position that provides output pulses with positive-going leading edges (see scope grab – Fig.7).

Most GPS receiver modules, including those specified here, provide 1Hz pulses with this polarity anyway, so the jumper shunt will probably need to be in the upper position; ie, so that



This view shows the GPS 1pps Timebase module mounted inside the 2.5GHz 12-Digit Frequency Counter. Note that the unit must be mounted on the lid so that it sits horizontally – important for the antenna to function effectively.

the pulses are taken from the non-inverting buffer output (collector of Q2).

Mounting

Fig.5 shows how the timebase PCB is mounted inside the counter box. This is the easiest mounting option and if you're using the EM-406 GPS module (which is quite sensitive), it and others should be perfectly workable even if you are inside a building.

There are just three connections to be run to the main counter board: 1pps signal, +5V and ground (GND). Fig.4 shows the wiring details. As you can see, the ground wire connects to the ground pin just to the right of IC6, while the +5V wire connects to a PCB via to the left of IC23. The wire carrying the 1Hz pulses from the GPS receiver connects to the righthand end of the 1kΩ resistor behind CON3.

On the timebase board, the +5V lead connects to the +5V pad, the ground wire to the GND pad, and the signal lead to the "1PPS" pad. These pads are also labelled "1", "2" and "3" (corresponding to the pin numbers for CON1, which is left out if the timebase is mounted inside the counter case).

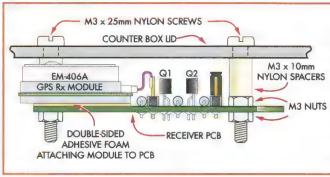


Fig.5: the timebase module is attached to the lid of the case on M3 x 10mm untapped Nylon spacers and secure using four M3 x 25mm Nylon screws and eight M3 nuts (four used as spacers).

Putting it to use

There are no setting-up adjustments to make before the GPS 1pps Timebase is put to use, apart from setting jumper shunts LK1 and LK2 to suit the GPS receiver module you're using. Jumper shunt LK1 is simply placed on the right if the module needs 5V, or on the left if it needs 3.3V.

In most cases, jumper LK2 will need to be placed in the "upper" position, although there may be some GPS

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	22kΩ	red red orange brown	red red black red brown
❑	1	10kΩ	brown black orange brown	brown black black red brown
❑	2	2.2kΩ	red red red brown	red red black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown

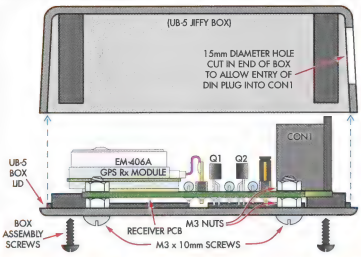


Fig.6: here's how to install the GPS 1pps timebase module in a UB-5 jiffy box. The module (with CON1 installed) mounts on the case lid.

Building A Standalone 1pps Timebase

Some GPS receivers may not have sufficient sensitivity to work indoors. In that case, it will be necessary to install the timebase PCB in a small utility box which can then be positioned on a window sill (or wherever) for better satellite-reception. The unit can then be connected to the counter via a cable fitted with DIN plugs at either end.

Fig.6 shows how the unit is mounted inside a UB-5 jiffy box. You will need to mount DIN socket CON1 on the PCB, then attach the PCB to the case lid using four M3 x 10mm machine screws and eight nuts (four used as spacers).

A 15mm-diameter hole will then have to be drilled and reamed in one end of the box, in line with the DIN socket (ie, to allow plug entry). In addition, a matching 5-pin DIN socket should be mounted on the rear panel of the counter and its terminals run to the corresponding pads on the main counter PCB.

Finally, you will have to make up a suitable cable with DIN plugs to connect the two units together. This can be made up using shielded 2-core audio cable (red lead = +5V, white lead = 1pps signal and shield = GND).

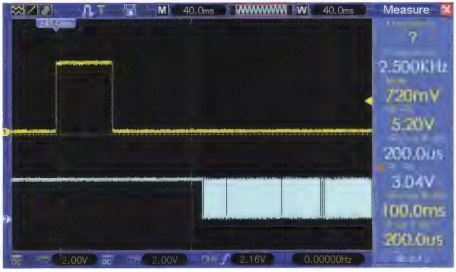


Fig.7: the 1Hz pulses from the timebase must have positive-going leading edges as shown on the upper trace of this scope grab. In most cases, the GPS module will provide pulses with this polarity, so link LK2 will have to go in the upper (non-inverting) position. If not, then set LK2 to the lower (inverting) position.

modules which need it in the lower position. If you are in doubt about this and you have access to a scope, use it to check the polarity of the 1Hz output pulses. The 100ms-wide pulses should be positive-going, as shown in Fig.7. If they're not, the remedy is to fit LK2 to the lower position.

Alternatively, if you don't have a scope you can easily determine the correct position for LK2 by trial and error.

Be aware that most GPS receiver modules will take some time to achieve a "fix" from the GPS satellites after they are powered up. This start-up period can be as long as 70-80 seconds, depending on the GPS module's sensitivity, your location and the signal strength from the GPS satellites.

This means that until the module does achieve a fix, the 1Hz pulses from it will either be non-existent or "free running" – ie, not locked to the GPS time reference. So don't expect to be able to make high-accuracy measurements right from switch-on. You'll need to wait a couple of minutes while the GPS receiver locks on to the GPS signals.

While you are waiting and assuming that you have selected the External Timebase option, the 12-digit counter will not usually show any measurement. Instead, it will continue to display "SILICON CHIP" until pulses are received from the timebase.

If you are impatient and don't want to wait for the GPS 1pps timebase to achieve a fix each time you switch the counter on, there's a remedy for this too: keep it permanently powered from a separate 5V DC plugpack. That way, the GPS-locked 1Hz timebase pulses will be available to the 12-Digit Frequency Counter whenever you want to use it. SC

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Premium UHF Two-Way

Not long before Christmas, we were approached by a Sydney company, HB Wireless, to look at one of their "flagship" portable UHF transceivers, the Korean-made XR-450M.

According to HB Wireless, they have had a lot of success in the commercial market with this particular radio due not only to its high performance (see spec panel) but also its ruggedness.

Mining and construction companies, renowned for their ability to break the unbreakable, have been some of their biggest customers.

Some of the features of the XR-450M – the "lone worker" function, for example, where a worker needs to make a call within a designated time – make it particularly attractive to organisations in security industries and those in remote areas.

It's rugged, with an operating temperature range of -30 to +60°C and humidity to 95%.

The fact that it covers the full land mobile band from 450MHz right up to 512MHz (many only do 450-470 or 470-490), meets military specs MIL 810C, D and E and is IP68 waterproof (more on that shortly) is also testament to the quality of this particular transceiver.

Add to that its tiny size (103 x 52 x 32mm) and weight (250g with battery) – so it easily fits in the palm of your hand – and it's not surprising that it has become so popular.

Crowded market

The "land mobile" UHF transceiver market is becoming quite crowded but is dominated by a couple of well-known brands. Breaking into this market has not been easy and, in fact, there have been casualties along the way. HB Wireless is determined not to be one of those, setting itself apart as a supplier of premium product with premium backup.

They offer a two year "hot swap" replacement warranty on all portable transceivers.

Waterproof

We mentioned that this transceiver is IP68 waterproof a moment ago but what does this actually mean?

IP68 is the highest specification under the "IP" (Ingress Protection) standard – actually an international standard EN 60529.

The first of the two digits refers to intrusion protection, ranging from 0 (no special protection) up to 6 (totally dust tight). The second digit refers to moisture protection, again ranging from 0 (no protection) up to 8 (protected against prolonged effects of immersion under pressure).

This means that it can be fully immersed (to a depth of five metres) and will operate as soon as it surfaces.

Radio from HB Wireless

This would make the XR-450M an ideal radio for such organisations as surf lifesaving, coastal patrol, marine search and rescue etc – all of which regularly "lose" radios due to inadvertent dunking. In the vast majority of cases, especially in salt water, this is terminal for that radio. Here it is not even an inconvenience!

And speaking of inconvenience, most of the organisations mentioned insist that hand-held radios are used inside a waterproof bag – which is fine until the radio is dropped in the drink and you only then find out that it has a few tiny holes! Experience? Umm . . . (Many users find the waterproof bag also tends to attenuate or muffle received signal).

What else can it do?

Again, we refer you to the spec panel but briefly, some of the standouts are:

- 512 programmable channels in 16 groups (ideal for companies with various workgroups)
- 128 x 16 dot LCD
- Scramble function using frequency inversion (won't stop a determined listener but will stop the casual "scanner").
- Built-in compander
- 4.5W transmit power (on high, 2W on low); and 1W audio
- Remote "stun" and "unstun" function (if the radio is stolen or lost, you can remotely disable it to prevent use/interference/espionage).
- User programmable (with appropriate software and cable); radios can be "cloned" one to another.
- Ability to work as repeater (with second radio and cable).
- Multi-connector compatible with the popular GP-628 plus standard.
- 4.5 hour quick charge (mains charger supplied)
- Meets CE, Australian/New Zealand (4294:2004), FCC and Canadian standards.

With a price of $378.00 including GST and freight, the XR450M is certainly not the cheapest hand-held UHF transceiver you will find. But one with all these features? It really offers excellent value for money (particularly with the level of support offered).

And while it *can* be programmed with UHF CB frequencies (~476MHz), this is not its market: the XR-450M is specifically aimed at the land mobile market, commercial users who demand performance and reliability.

If the price tag presents a problem, HB Wireless also offer the lower-spec XR-450R (eg, no IP68, no display, covers 450-512MHz, etc but otherwise similar to XR-450M) for $279.00

All transceivers come with battery, charger, USB computer connector and programming software, whip antenna, belt clip and instructions. A range of accessories is also available.

HB Wireless claim the XR-450M is the strongest and highest specification radio ever sold and, while we cannot of course verify that claim, we couldn't argue with them after playing with this little beauty.

Having "played" with literally hundreds of transceivers over the years, I'd have to rate this one as right up there. (RT)

Contact HB Wireless at 202 Whitford Rd, Green Valley, NSW 2168. Tel (02) 8763 7651; Web www.hbwireless.com.au

- Frequency range: 450MHz ~ 512MHz
- 512 channels in 16 groups
- Nominal voltage 7.5Volts DC
- Channel Spacing: 12.5 and 25kHz programmable
- Coverage (open space) Up to 8km
- TX up to 4.5W; low power 2W (switchable)
- Military Specs. MIL810C, D, E & IP68 waterproof
- 128x16 dot graphic LCD with backlight
- Programmable channel name tag
- Built-in compander & voice inversion scrambler
- Five-Tone,Two-Tone Encode & Decode
- Selcall/ANI with five-tone or DTMF
- Emergency call & lone worker function
- Stun/Revive, VOX, BCLO, power save & TOT
- Low battery alert, signal & battery indicator
- Multi-pin aux. connector, compatible with GP328+
- Ergonomic design
- Approvals: CE, FCC, AS/NZS 4295:2004
- Dimensions: 103mm(H) x 52mm(W) x 32mm(D)
- Weight: 250g with 2200mAh battery

It's tiny, it's waterproof, it's programmable, it packs a punch . . . it's the XR-450M UHF handheld transceiver from HB Wireless.

Vintage Radio

By Rodney Champness, VK3UG

More Philips Twins – the Dutch 209U and the Australian 112A

Continuing on with our series of Philips twins, this month we take a look at the Dutch Philips 209U multi-band receiver and its Australian "twin", the model 112A. Under the skin though, these are two very different receivers.

LIKE OTHER Dutch/Australian Philips twins, the 209U and 112A receivers look the same at first glance but on closer inspection, are as different as chalk and cheese. In this case though, there is a slight difference in cabinet size, so the Dutch parent company obviously produced more than one variant of this particular cabinet style with only minor differences between them.

As before, the cabinet moulds for the Australian-built receiver were obtained from the parent company, probably after the parent company had finished with them. The Dutch 209U receiver was manufactured from 1946-1947 while its Australian look-alike was produced somewhat later, from 1948-1949.

Model 112A circuit details

Fig.1 shows the circuit details of the Australian Model 112A. It's a fairly conventional 4-valve superhet receiver with 455kHz IF stages.

As shown, the antenna signal is fed to a tuned circuit consisting of L1 and C1 and resonates at a frequency just below the broadcast band. This boosts the sensitivity of the receiver at the low-frequency end of the band, while trimmer capacitor C2 boosts the performance at the high-frequency end by feeding signal into coil L2. The signal in L1 also inductively couples into L2.

Basically, the tuned antenna circuits in sets of this era and later were designed to extract the maximum amount of signal from relatively short antennas. In effect, this was done by partially tuning the antenna using fixed value components. This technique significantly improved receiver performance compared to sets using the antenna-tuned circuits of the 1920s.

As an aside, to get the best performance from crystal sets, additional tuned circuits for the antenna are used. These must be capable of tuning the antenna right across the band, as in the crystal set described in the April 2007 issue. In addition, high-frequency 2-way radios must also

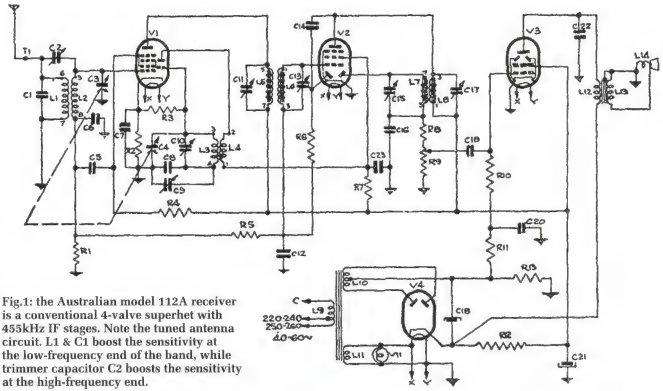


Fig.1: the Australian model 112A receiver is a conventional 4-valve superhet with 455kHz IF stages. Note the tuned antenna circuit. L1 & C1 boost the sensitivity at the low-frequency end of the band, while trimmer capacitor C2 boosts the sensitivity at the high-frequency end.

have fully tunable antenna circuits (ie, the antenna must be tuned to the operating frequency) if they are to work efficiently.

Getting back to Fig.1, the RF signal from the antenna circuit is tuned using C3 (one section of the dual tuning gang). The resulting signal, in the range from 530-1620kHz, is then applied to the signal grid of V1, an ECH35 converter.

Note that no provision has been made to adjust the inductance of L2, so it cannot be peaked at the low-frequency end of the tuning range. However, by adjusting the position of the dial pointer and adjusting the oscillator padder capacitors to suit, some peaking the set's low-frequency performance is possible. It's a fiddly process though and doesn't always achieve perfect results (the article on alignment in the February 2003 issue described the techniques necessary for good results).

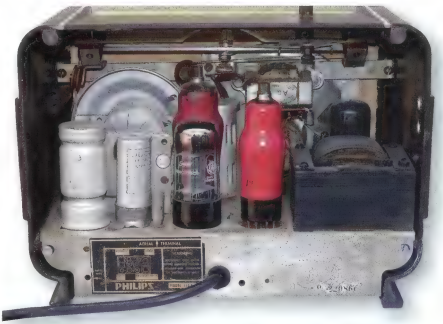
At the other end of the band, C2 is adjusted to peak the performance at around 1500kHz.

Local oscillator

The local oscillator is based around V1, coils L3 and L4, the other section of the tuning gang (C4) and their associated components. The values of padder capacitors C8 and C9 are adjusted so that stations appear at the correct position of the dial at the low-frequency end of the tuning range, while C10 is used to do the same thing at the high-frequency end.

V1's output appears at its plate and this is coupled to a double-tuned 455kHz IF (intermediate frequency) transformer. The resulting 455kHz IF signal is fed to V2, an EBF35, where it is further amplified and then applied to another double-tuned 455kHz IF transformer. Its output is in turn fed to a detector diode in V2.

The resulting audio signal from the detector appears across R8 and volume control potentiometer R9. From



The view inside the model 112A receiver. The chassis is well laid out and all parts are readily accessible.

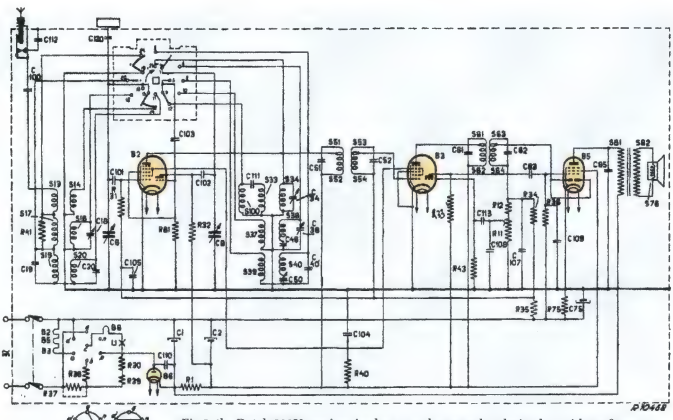


Fig.2: the Dutch 209U receiver is also a 4-valve superhet design but with performance equivalent to a 5-valve circuit due to the dual role performed by valve B2 (see text). It's a multi-band design and is more complicated than the Australian model 112.

there, the signal is fed via C19 to the grid of V3, a 6V6GT audio amplifier stage. This stage in turn drives the loudspeaker via an output transformer (L12/L13). No negative feedback is used in the audio amplifier.

Simple AGC

The IF signal level at V2's plate is greater than it is at the detector diode and this signal is also applied to the AGC diode via C14. This set has simple AGC and as soon as there is any signal (including any interference or other noise), a small AGC bias appears on the AGC diode. This is a good design feature as V2 has no standing bias and the set will normally be tuned to a station. However, it would not be considered good design practice in a communications receiver.

By contrast, the converter stage (V2) does have standing bias due to the voltage across R2. Note that the converter receives just 20% of the AGC voltage applied to the IF valve due to the voltage divider formed by resistors R1 and R5.

The power supply is designed to operate off voltages from 220-260VAC at 40-60Hz. Australia now has 50Hz mains but 40Hz was used in Western Australia for some time and 60Hz is used in the USA (although it's doubtful that Philips exported this set to the USA). However, it was a good selling point and it's possible that some of the home-lighting plants of the era ran at 60Hz.

Power transformer

The power transformer has two secondaries: (1) 6.3V for the valve heaters and dial lamps and (2) a 376V centre-tapped secondary for the HT (high tension). Note resistor R13 (250Ω) between the centre tap and the chassis. The voltage developed across this is fed to V3's grid via R10 and R11 and provides a bias of -9V for this stage.

Finally, resistor R12 decouples the HT supply at V3's plate from the HT line fed to other sections of the receiver. This is good design practice as it minimises IF and audio feedback between the stages.

The Dutch 209U circuit

Now let's take a look at the circuit for the Dutch 209U receiver – see Fig.2.

This is a very different circuit to the one used in the 112A. It's also a 4-valve superhet receiver but in this case, the first stage uses a UCH21 triode heptode (B2). This valve can be used as a separate pentode and triode and/or as a converter. In this receiver, it is used as both and so it has the performance of a 5-valve set.

Unlike the 112A, which tunes the broadcast band only, the 209U is a multi-band receiver. The tuning ranges cover three bands: 157-400kHz long wave, 530-1600kHz medium wave (broadcast band) and 5.88-18.2MHz shortwave. In addition, this receiver is designed to work on both AC and DC mains and as such, can have a live or "hot" chassis.

Hot-chassis sets are considered by most vintage radio collectors to be dangerous to work on, as any carelessness can lead to a severe electric shock or even death. In fact, they are often shunned because of this and only those who know what they are doing and are aware of the dangers should work on them

That said, a receiver that uses a power transformer to isolate the

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Corrosion prevention in an air-conditioner

Thanks for your informative article on replacement of sacrificial anodes in hot-water systems in the November 2012 issue. Another common expensive home appliance that is subject to rust is the external compressor of ducted/split air conditioners. Do you have any suggestions as to how to prevent rust here? Would "electronic" rust protection as installed in motor vehicles work? (J. F., via email).

● Unfortunately, you cannot use sacrificial anodes for protecting structures that are not at least partially immersed in water, eg, boats. You have to rely on primary methods such as galvanising and paint.

In fact, we were recently concerned about the large split aircon system which serves the SILICON CHIP offices as it was starting to look a bit tired, even though it is serviced every six months. To that end, we had the rusting screws replaced with stainless steel screws and then had the cabinet painted (at the same time as the roof of the building).

We do not think electronic rust protection systems in cars actually work. They are often sold and fitted to new cars but modern cars have such good paint (with a 5-year warranty being standard) that most owners would never know if the electronic system was a benefit or not.

SLA battery charging with a bench-top supply

How do I recharge an SLA battery with just a standard bench-top power supply? I ask because I inherited a nice 24V SLA but my SLA charger does not have a 24V range. I believe it can be recharged with a standard variable power supply via a limiting resistor but what voltage should I set it to and what value of resistor should I choose?

Is there a formula for this? Also, seeing the power supply has current limiting, can this be utilised?

The rating of the battery is a nominal 24V at about 3.6A. The 12V SLAs I recharge are rated at 2.2A and it would be handy to recharge these from the power supply as well. (B. A., via email).

● Typically, an SLA battery can be charged at up to 25% of its Ah capacity. So, for example, a 10Ah battery can be charged at 2.5A.

You can charge the battery via a power supply and limiting resistor. Set the supply to 14.4V for a 12V battery and 28.8V for a 24V battery, or use the manufacturers' charging end-point voltage that is usually shown on the side of the battery.

The resistor is there to limit the charging current, typically to the maximum the battery can accept. Assuming the battery is at 23V and the supply is

Running An Ultra-LD Amplifier From Higher Voltages

I have recently acquired a Pro Series 3 Amplifier with a Pro Series 4 Preamp. I already had a Pro Series Amplifier which I have used for many years.

In one of them, I was quite keen to replace the stock Mosfet power amplifiers with the new Ultra-LD Mk.3 boards, as this might offer some noticeable improvements. The obvious problem is that the Pro Series power supply is 70-0-70V which is a tad more than 57-0-57V. I really do not want to purchase new transformers. Will the amplifiers work on the higher voltage or will it kill them? (J. S., via email).

● You can't run the Ultra-LD Mk.3 amplifier module as published from ±70V because its supply bypass capacitors are only rated at 63V. Also, the collector-emitter voltage rating of Q3 and Q4 (BC546) is 65V.

In theory, you could upgrade some components and it would operate from a ±70V supply but it would only be suitable for driving load impedances of 8Ω or above. We published the load lines on page 34 of the July 2011 issue (Fig.6) and this shows how close the 4Ω load line is to the 1-second SOA of the output transistors with the recommended ±57V (nominal) supply. With ±70V and a 4Ω load you would be at serious risk of second breakdown in the output transistors if you drove the amplifier hard.

If you *really* do want to try modifying it to run at a higher supply voltage, you would need to change the following components:

(1) 2 x 1000µF 63V capacitor rating must be increased to 80V or 100V;

(2) the 470µF 63V capacitor rating must be increased to 80V or 100V;

(3) the four 100nF supply rail bypass capacitors (two for each rail) need to be rated at 100V;

(4) the 47µF 35V capacitor which connects to the junction of the two 6.2kΩ resistors (at the collector of Q7) needs to be rated at 50V or 63V;

(5) Q3 and Q4 would need to be changed to a high-voltage type such as MPSA42. Note that these have the opposite pin-out to BC546s so you would need to install them the other way around.

We advise caution if you decide to proceed as we haven't tested the amplifier module at such a high voltage. While we think the above changes should be sufficient to prevent immediate failure, the increased dissipation in the output transistors could be an issue. Having said that, if you aren't going to be driving it particularly hard, it may be OK.

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mains from the chassis can be quite dangerous too, as these may have an HT rail voltage in excess of 500V DC (ie, across the main electrolytic filter capacitors) soon after switch-on. This HT rail is also capable of delivering a fatal electric shock and so all sets need to be treated with respect, not just the hot-chassis AC/DC types.

Valve heater voltages

The valves used in the Dutch 209U receiver have 20V, 50V or 55V heaters, each rated at 100mA. As a result, when these are connected in series, a heater supply rail of 20 + 20 + 55 + 50 = 145V is required. Connecting a resistor or resistors in series with these heaters allows the set to be operated from 220V.

If the set is to operate from 125V, the heaters are instead switched into two strings with three heaters in series on one string and the rectifier heater on the other. Series resistors are then used to reduce the voltage drop across each string to the required 125V.

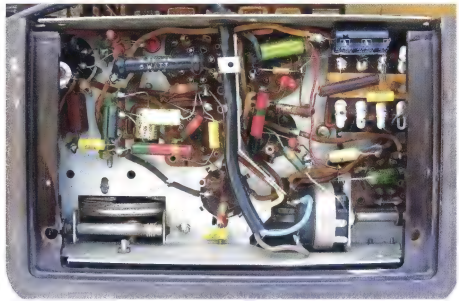
The necessary switching to do this is achieved via a plug-and-socket arrangement on the rear apron of the chassis. By changing the wiring to a couple of resistors in these strings, it's also possible to run the set on either 110V or 200V. The wiring is such that when used on AC, the HT voltage is of the order of 150V. When operated from 220V, the current drain is around 100mA for the heaters plus a further 70mA for the plate and screen loads of the valves.

Because this is an AC/DC receiver with a "hot" chassis, the antenna lead has a capacitor in series with it, so that no voltage appears on the antenna. There is no earth on this set; instead, it relies on the mains to effectively act as the earth.

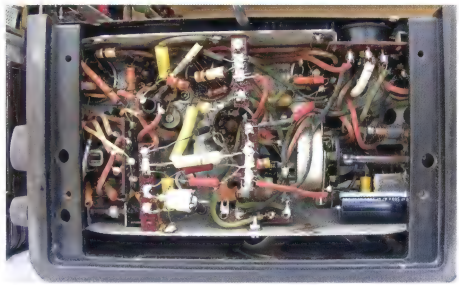
Foil plate antenna

In addition to the external antenna, there is also a foil-plate antenna on the inside of the back panel of the receiver. This is also isolated by a capacitor to make sure no mains voltage appears on it. This antenna is shown at the top-left of the circuit diagram and is connected to the signal grid of the UCH21 triode-heptode converter valve (B2) via C120 and C101.

When aligning the receiver, this plate antenna must be attached and the back panel fitted in place as it affects the antenna input tuning adjustments at the high-frequency end of each tuning range.



This view of the model 112A shows just how few parts there are underneath the chassis. Note that this photo was taken before the power cord was rewired and properly clamped into position (the Earth connection was also later improved).



The Dutch 209U's chassis is more crowded than the model 112A's and is further complicated by the band-switching arrangement at lower left. As a result, it's the more difficult of the two sets to service.

As shown in Fig.2, all the antenna input coils are wired in series and various sections shorted to earth as required. At the same time, the secondaries are switched to valve B2's signal grid, depending on the selected frequency band. The oscillator circuits are also switched as required to the triode section of the B2 converter valve.

The mixed signals appear at the plate of B2 and are fed to a double-tuned 452kHz IF transformer (S51-S54). However, one version of the receiver has an IF of 468kHz.

Next, the resulting 452kHz IF signal is fed to the signal grid of the heptode section of valve B3 (UCH21). B3 amplifies this IF signal and it is then fed through a second double-tuned IF transformer. It then goes to the detector and AGC diodes in B5, a UBL21 duo-diode-power pentode valve.

The detected audio appears across resistor R12 and volume control potentiometer R11, with the signal at R11's wiper then fed to the grid of the triode section in valve B3. The amplified signal from B3 is then fed via C83 to the pentode section of audio output

at 28.8V (24V battery), then the resistor value should be (28.8V - 23V) ÷ (the maximum current). Of course, this also assumes that the supply can deliver the necessary current.

The power dissipated in the resistor is the maximum current squared times the resistance (ie, I^2R). You must use a resistor with a higher power rating than the wattage calculated. The battery will be charged when it reaches 28.8V.

For example, for a 10Ah battery, the resistor value would be (28.8V - 23V) ÷ 2.5 = 2.32Ω, which means you could use two 1.2Ω 10W resistors in series.

Battery voltage does not indicate state of charge

I have an issue that neither I nor my auto-electrician can explain. I have been having car battery charging issues due, as it turned out, to a faulty alternator which could not achieve the correct voltage output under load. The car in question is a 2000 Ford laser GLXi 1.8L (116,000km) which uses both the ECU and an internal alternator regulator to control alternator output.

Recently, the alternator was reconditioned and a new battery fitted. From a voltage standpoint all now looks good: static battery voltage of 12.7V; maximum charging voltage of 14.2V and a floating charge rate of around 13.8V. The charging voltages are maintained under load.

However with a fully charged battery, engine running, an alternator/battery voltage of 14.2V and the headlamps on, a Hall Effect ammeter shows a discharge of around 5A which to me is seemingly impossible with a voltage of 14.2V. The auto-electrician's clamp meter confirmed the reading to be correct. Increasing engine speed did not materially affect the reading.

The alternator is rated at 80A and can provide this level of current if connected to a discharged battery. What could explain this apparent anomaly? Could it be that the ECU, which follows engine temperature/loading/fuel economy etc, is sensing that the battery is fully charged and therefore "allows" the battery to provide some of the current requirement rather than increasing the alternator output until such time that the state of charge is reduced?

In support of this latter supposition the engine was stopped and a major load (the CCA test) was applied for around 20 seconds and the engine restarted. Now with the headlights on, a significant charge was going into the battery. I would just like to understand what is happening! (M. F., Mount Eliza, Vic).

● There can be several processes going on. First, you need to note that the clamp meter does not provide a full picture of what is happening. The clamp meter will be reading the net current flow rather than the separate charge current into the battery and the separate discharge current into the headlamps. So the discharge current flows in one direction and the charging current in the other direction subtract to produce an overall difference current. It is this difference current that the meter reads.

You may find that there could be a complete balance where charge current equals discharge current and so the ammeter will read 0A even though there is current flow. At other times, the discharge might be less than the charge current for a positive current reading. When the discharge is greater than the charge, the current reading will be negative.

Nor is battery voltage an indicator of battery charge state. A reading of 14.2V does not necessarily mean that the battery is fully charged. The ECU just maintains the 14.2V so that the battery will not overcharge. Typically, a battery will only be 90% charged when it first reaches 14.2V and it will continue to charge at that voltage, with the current tapering off as it fully charges. Similarly, a 13.8V voltage reading does not mean the battery will accept any more charge since this float voltage is sufficient to maintain full charge.

The battery charge current is dependent on the state of charge of the battery. It will not accept charge current when fully charged, regardless of the terminal voltage. If the alternator can deliver the load current then the battery will remain charged. If the battery is fully charged and a load placed on it, the alternator may not initially

SoftStarter No Good For A Hair Dryer

The Power-Tool SoftStarter in the July 2012 issue interests me. I use a 2.3kW petrol-driven generator to operate my power tools. When I turn on my 1500W hair dryer, the poor generator staggers a bit before managing the load. So the Soft Starter should make life easier for the generator. Is this so? (S. S., via email).

● We wouldn't expect the Soft Starter for Power Tools to help much in this situation. The problem you have is not due to a high inrush current. Hair dryers/hot-air blowers are more or less resistive loads and draw an essentially constant current. We measured our lab 1500W hot-air blower at 41Ω when cold which equates to about 230 x 230 ÷ 41 = 1290W.

The generator staggering is due to the fact that it has to open its throttle in response to the sudden increase in load but it can only sense this by a drop in the output voltage and/or RPM. It then takes a little time for the motor to increase its power output in response and a little while longer before a new equilibrium is reached.

If you can slowly ramp the load up, then the generator will have longer to respond and so may not stagger as much. While the Soft Starter does this, its effect is probably too small; it's designed to suppress very short, very high current transients. For a start, the two NTC thermistors have a series resistance of around 20Ω when cold compared to the hair drier at around 40Ω, so it will only reduce the initial current by about one third. They will also heat up pretty rapidly, over a fraction of a second, and allow virtually the full current to flow.

You're probably better off using a simple AC motor speed controller and simply starting the hair drier at minimum power and then ramping it up over a couple of seconds to full power. Our 230VAC 10A Full-Wave Motor Speed Controller from the May 2009 issue should do the job.

However, note that if the hair drier has a half-power setting, this probably won't work when used in conjunction with the Motor Speed Controller. You will have to use the Speed Controller to adjust the power instead. Note also that you shouldn't run the hair dryer at a low setting for very long as the air flow may not be sufficient and it could overheat and melt its housing.

Christmas Light Controller Keeps LEDs Partially On

I recently decided to build the Christmas light project (SILICON CHIP, October, November & December 2010) and have purchased a number of these lighting controller kits. When I connect all the components together I get an unexpected result. When I turn the system on, the LED strings turn on dimly and remain on for the entire duration of the "show".

Everything works perfectly in the system other than the lights will not turn off completely. I have played around with some of the settings in the configuration file on the SD card and have seen the results change. If I do not enter the *Slave = DC* line for the controller, the lights still remain on for the duration of the show but do not switch correctly as they do with this line of code.

I have similar results with the *Triac = delayed / immediate* line. I run the configuration file with the suggested settings as per the kit instructions.

If I turn the system on without an SD card or without any data on the SD card, the slave kit does not allow anything to turn on at all and even the dimly lit issue does not occur. As soon as the lights turn on for the first time they then remain on for the duration of the system being powered up. Switching between slave kits yields the same result. As such, I suspect either the configuration file or the master kit. Any suggestions to help me resolve this would be greatly appreciated. (G. H., via email).

● This sounds like it is due to the "filament preheat" feature, intended to prolong the life of incandescent lamps that may be connected to the unit. This feature is not automatically turned off when you use a slave in DC mode, so you need to turn it off separately.

If filament preheat is left on for a DC slave, it effectively sets a minimum duty cycle and so the LEDs will remain dimly lit at all times (except for when they're driven more brightly). There are two ways to turn it off. You can either turn it off for all slaves with a line like this in the configuration file:

filament preheat amount = 0

or you can turn it off on a per-slave basis with a line like this:

filament preheat 1 = no
filament preheat 2 = no
etc.

provide charge to the battery.

With little loading on the battery, the ECU may have the battery set to float at the lower voltage. A change in load current may then result in the ECU allowing the battery voltage to rise up to 14.2V but with no added charge current flowing. So the clamp meter reading will fluctuate depending on the load and the battery state.

NTC thermistor heat question

In your SoftStarter project, April 2012, you said the NTC thermistor could not be left permanently in-circuit as it would run hot, thus you had the delayed relay to bypass it. However, in the Induction Motor Speed Controller, in the same issue, the same NTC is left permanently in-circuit. Isn't this a contradiction? (D. H., via email).

● We don't want the hot NTC thermistor in a tiny plastic enclosure which might melt. That's not a problem in the much larger case of the induction motor controller which already has a large heatsink inside it.

Courtesy light inhibits central locking

I have an interior dome light kit which works a charm, but I can not activate my central locking until the lights go off. Is there a way to modify the circuit or get a different power feed to fool the system into thinking the lights are off when they are not and so forth? I want it so that central locking can be utilised straight after the door is closed.(M. J., via email).

● We are not sure what the central locking is detecting with the interior lights on. It is probably the current through the interior lamps.

You may have to experiment with the interior lights wiring to find out which wiring method solves this. Perhaps a separate 12V supply from the battery via a fuse would solve it instead of the original interior lighting wiring via the original fusebox.

L'il Pulser train controller

Many moons ago you published an article on building a L'il Pulser Model Train Controller (SILICON CHIP, February 2001) and subsequently Dick Smith sold a kitset. I recently got around to building it and this is my very first attempt at building anything electronic.

All went very well until I discovered the relay supplied in the kit did not fit the PCB but I got around that by getting a replacement from Jaycar. I finished the job and ran the test routine using an unregulated 12V DC supply off my Hornby train controller.

In forward mode, the track voltage LED remained a constant green when it should have grown brighter with changes in the speed pot. I adjusted VR3 correctly to 2.0V. The piezo works but not when I short the outputs.

If I place a loco on the track it is no go. The speed LED is a constant weak green at zero but starts flashing green when VR1 is wound up – still rather weakly. VR2 was adjusted without the loco and set to mid-point. I checked the output at full speed and the best I can get is 5.7V.

I cannot see any errors. The only one thing that slightly bothers me is diode D3. It's very tiny but I am pretty sure it's installed correctly with the cathode (black ring) to the left as I look at the circuit. (D. J., via email).

● Using a multimeter set to DC volts, check the output of IC2a at pin 7. This should vary from approximately 3V to 9V as VR1 is adjusted. This voltage range is dependent on VR2's setting.

If this is not correct, check the placement of all components. The D3 orientation you mention is correct. Make sure all components are soldered in place and that the wire links (shown as a line on the overlay) are installed.

Also check if there is low resistance between the 17V supply and one side of the motor output terminal, then check for low resistance between the other side of the motor terminal and the drain of Q1. This checks the relay

contacts and you should get a reading of below 1Ω. With reverse, the low resistance between the 17V rail and Q1's drain should be on the opposite terminals.

Upgrading the solar charge controller

I built the MPPT Solar Charger Controller from the February 2011 issue and it works great. However, I've upgraded my hardware and I need to figure out the design modifications required to amp it up. I now have a 175W panel and a 200W panel. I'm also charging two N120 batteries, ie, two 120Ah 12V in series for a 24V configuration. The inductor seems to be overheating (not surprising) and reaches over 95°C. I suspect this means also that the inductor is saturating.

The problem is the unit does not produce 28.8V across the batteries, even when the batteries have been fully recharged prior to switching the module into circuit. I'm wondering if my unit is actually faulty? Essentially, as far as I can read the schematic, I may need to duplicate the power line of the design, duplicating diodes, Mosfet, capacitors and inductors. However, after much contemplation, I suspect a modified design for the inductor will likely suffice.

Even running as it does, the unit switches into float mode after reaching a terminal voltage of 25.5V. The indication is that something may be faulty. I adjusted the voltage feedback to trick the system into running the bulk phase longer and so far this has not been a problem.

The set-up I have is quite interesting in its own right and forms the cornerstone of an eco-living project. The batteries are driving a 3kVA inverter that easily runs a 25% duty cycle switchmode arc welder! So I can weld in the bush and use a drop saw and other power tools for mobile repairs. I run a home-maintenance business and even in the city when I've fronted and a customer wasn't home and no external power points were available, my rig got the job done without resorting to a generator.

I've also tried running a fan directly on the circuit board with cover removed, after I found that bolting a heatsink to the case didn't perform well enough. Unfortunately, the case lid holes don't nicely line up with an off-the-shelf DC motor, which could be run by the PIC if you wanted to get fancy. But even running continuously would probably help in my intended scenario.

I was wondering if the internal resistance of the batteries (as they are real whoppers) is significantly lower than, say, a 40Ah battery designed to deliver 400 CCAs. These puppies will spit out something like 860 CCAs. Any additional information you can provide for this kit would be welcome. I am an electronics engineer, although a little rusty as I'm not working in this field on a regular basis. (P. H., via email).

● As far as the inductor is concerned, you could try to increase the current

continued on page 96

Hum Problem In Preamp And Amplifier

I recently built a Studio Series Preamplifier together with the 20W Class-A Amplifier. The amplifier is excellent but when I connect the preamplifer, it makes an annoying humming sound. I have tried to follow the instructions about earthing but it has not gone as planned. I have probably missed or misunderstood something. Also, I have replaced the main switching board inside the unit but the hum is still there.

I have tried to connect the preamp to the amplifier with an earth wire as well. Although the hum has reduced, it has not gone away completely. Can you tell me what I am doing wrong? It appears like it's an earthing problem – maybe an earthing connection within the case which I missed out. (C.T., via email).

● There are several reasons why hum can be introduced into audio signals. If each piece of equipment is OK separately but there is hum when you combine them then that suggests an earth loop is the cause. There is a paragraph towards the end of the construction article (page 72, July 2006) which says: ". . . if you notice more hum in your audio system after connecting the preamp, then try disconnecting the earth wire to the preamp module. Never, ever disconnect the mains earth from the chassis!"

That is what you will have to do. You can just de-solder (or cut) the earth wire from the input board at the rear of the preamp. Don't change the other earth wires, ie, those going to the pot body and chassis.

It is normal to have the power amplifier earthed and the other equipment floating, to avoid this very problem.

If that still doesn't fix it, the problem is likely either a power supply rejection problem in the preamp (which may be due to a faulty component) or else hum coupling into the signal path due to mains cables being run too close to signal cables or signal-carrying PCBs.

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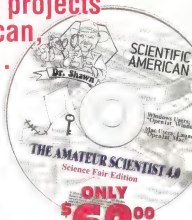

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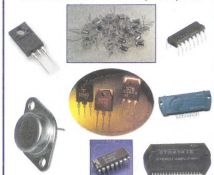

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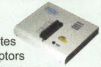

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. . . continued from p93

rating by stacking two cores together and winding 0.7 the number of turns originally specified around both cores.

The changes for a 24V battery are detailed in the original article in a separate panel. These include changes to the inductor windings. Note that diodes D1 & D2 are only rated for a 100W solar panel, not for 175W. Make sure that any higher-rated replacement diodes are also Schottky types so that the circuit can operate at 32kHz.

The low-ESR capacitors need to be increased in number to cope with the extra current. The PCB tracks and fuse are also not suited for the extra power involved and will need to be upgraded. The PCB tracks for the charging section could be beefed up with tinned copper wire.

High-energy ignition for old twin-cylinder

I have a 2-cylinder Kohler engine driving a wood chipper. Originally it had a "double-ended" ignition coil activated by a conventional set of points from a 12V battery. The coil was damaged beyond repair and a replacement was both expensive and hard to get so I ended up using two conventional 12V coils and condensers wired to the points to get the job we were doing finished.

This was some months ago and the decision has been made that the machine should be fixed properly. I thought about using one of your transistor ignition designs but didn't know if it would handle the two coils. I then went to see my friendly auto-electrician and spoke to him about using a Commodore ignition coil (which he gave me) but he says that they need a special driver. Jaycar has a number of electronic ignition kits but the people in the Port Macquarie shop were unsure as to what would be needed. (D. H., via email).

- If you only have one set of points driving a coil with two HT output terminals then a Commodore coil driven by our High-Energy Ignition System (Silicon Chip, November & December 2012) is the way to go. In fact, if you read the Jacob's Ladder article in this issue, you will see that we are using a version of our High-Energy Ignition. For your application, build the points version of the kit. Altronics or Jaycar can supply the kit. **SC**

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Notes & Errata

High-Energy Electronic Ignition System, Nov-Dec 2012: readers building the coil tester version of the High Energy Electronic Ignition System, as depicted in Fig.10 on page 50 of the December 2012 issue, should be aware that there is a risk of failure in the LM2940CT-5 regulator and the PIC microcontroller due to high voltage spikes superimposed on the common positive lead from the battery to the coil and the ignition module.

To avoid this risk, the coil tester should be built exactly as we have configured it for the Jacob's Ladder in this issue, including the added protection components for the regulator: 10Ω resistor, 13.6V TVS and 1000μF 25V DC input capacitor.

These additional components are not required for the other versions of the High Energy Electronic Ignition System.

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(M733)

(M734)

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- Powder-coated finish for heavy-duty service
- Dimensions of each louvre: 900 x 456 x 20mm

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(A440) (A442) (A444) (A446) (A448)

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- Dimensions of each louvre: 900 x 456 x 20mm

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(A430) (A432) (A434) (A436)

Optional Buckets - suits LP-900	CODE	PRICE
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